Chapter
The s-Block Elements

Topic-1: Group-1 Elements (Alkali Metals)

1 MCQs with One Correct Answer

1. The metallic lustre exhibited by sodium is explained by
(a) diffusion of sodium ions **[1987 - 1 Mark]**
(b) oscillation of loose electrons
(c) excitation of free protons
(d) existence of body centered cubic lattice

2. The pair of compounds which cannot exist together in solution is : **[1986 - 1 Mark]**
(a) $NaHCO_3$ and NaOH (b) Na_2CO_3 and $NaHCO_3$
(c) Na_2CO_3 and NaOH (d) $NaHCO_3$ and NaCl

3. The oxide that gives hydrogen peroxide on treatment with a dilute acid is : **[1985 - 1 Mark]**
(a) PbO_2 (b) Na_2O_2 (c) MnO_2 (d) TiO_2

4. A solution of sodium metal in liquid ammonia is strongly reducing due to the presence of **[1981 - 1 Mark]**
(a) sodium atoms (b) sodium hydride
(c) sodium amide (d) solvated electrons

4 Fill in the Blanks

5. The electrolysis of molten sodium hydride liberates ..... gas at the ..... . **[1989 - 1 Mark]**

6. Sodium dissolved in liquid ammonia conducts electricity because ..... . **[1985 - 1 Mark]**

5 True / False

7. Sodium when burnt in excess of oxygen gives sodium oxide. **[1987 - 1 Mark]**

8. The softness of group I-A metals increases down the group with increasing atomic number. **[1986 - 1 Mark]**

6 MCQs with One or More than One Correct Answer

9. The compound(s) formed upon combustion of sodium metal in excess air is (are) **[2009 - 5M, –1]**
(a) Na_2O_2 (b) Na_2O (c) NaO_2 (d) NaOH

10. Highly pure dilute solution of sodium in liquid ammonia
(a) shows blue colour **[1998 - 2 Marks]**
(b) exhibits electrical conductivity
(c) produces sodium amide
(d) produces hydrogen gas.

9 Assertion and Reason Statement Type Questions

Each question contains **STATEMENT-1 (Assertion)** and **STATEMENT-2 (Reason)**. Each question has 4 choices (a), (b), (c) and (d) out of which ONLY ONE is correct. Mark your answer as

(a) If both Statement -1 and Statement -2 are correct, and Statement -2 is the correct explanation of the Statement -2.

(b) If both Statement -1 and Statement -2 are correct, but Statement -2 is not the correct explanation of the Statement -1.

(c) If Statement -1 is correct but Statement -2 is incorrect.

(d) If Statement -1 is incorrect but Statement -2 is correct. **[2007]**

11. **Statement-1 :** Alkali metals dissolve in liquid ammonia to give blue solutions.
Statement-2 : Alkali metals in liquid ammonia give solvated species of the type $[M(NH_3)_n]^+$ (M = alkali metals).

10 Subjective Problems

12. Explain the difference in the nature of bonding in LiF and LiI. **[1996 - 2 Marks]**

13. Write down the balanced equations for the reactions when:
(*i*) Potassium ferricyanide reacts with hydrogen peroxide in basic solution. **[1989 - 1 Mark]**
(*ii*) Carbon dioxide is passed through a concentrated aqueous solution of sodium chloride saturated with ammonia. **[1988 - 1 Mark]**

14. Give reason of the following :
Sodium carbonate is made by Solvay process but the same process is not extended to the manufacture of potassium carbonate. **[1981 - 1 Mark]**

Topic-2: Group-2 Elements (Alkaline Earth Metals)

1 MCQs with One Correct Answer

1. A sodium salt on treatment with $MgCl_2$ gives white precipitate only on heating. The anion of the sodium salt is **[2004S]**

(a) HCO_3^- (b) CO_3^{2-} (c) NO_3^- (d) SO_4^{2-}

2. The set representing the correct order of first ionization potential is **[2001S]**

(a) K > Na > Li (b) Be > Mg > Ca
(c) B > C > N (d) Ge > Si > C

3. The following compounds have been arranged in order of their increasing thermal stabilities. Identify the correct order. **[1996 - 1 Mark]**

K_2CO_3 (I) $MgCO_3$ (II) $CaCO_3$ (III) $BeCO_3$ (IV)

(a) I < II < III < IV (b) IV < II < III < I
(c) IV < II < I < III (d) II < IV < III < I

4. Molecular formula of Glauber's salt is : **[1985 - 1 Mark]**

(a) $MgSO_4 \cdot 7H_2O$ (b) $CuSO_4 \cdot 5H_2O$
(c) $FeSO_4 \cdot 7H_2O$ (d) $Na_2SO_4 \cdot 10H_2O$

5. Calcium is obtained by **[1980]**

(a) electrolysis of molten $CaCl_2$.
(b) electrolysis of solution of $CaCl_2$ in water.
(c) Reduction of $CaCl_2$ with carbon.
(d) roasting of limestone.

6. HCl is added to following oxides. Which one would give H_2O_2? **[1980]**

(a) MnO_2 (b) PbO_2 (c) $BaO_2 \cdot 8H_2O$ (d) NO_2

7. A substance absorbs CO_2 and violently reacts with water. The substance is **[1978]**

(a) $CaCO_3$ (b) CaO (c) H_2SO_4 (d) ZnO

4 Fill in the Blanks

8. Ca^{2+} has a smaller ionic radius than K^+ because it has ..... **[1993 - 1 Mark]**

9. Anhydrous $MgCl_2$ is obtained by heating hydrated salt with ..... **[1980]**

5 True / False

10. $MgCl_2 \cdot 6H_2O$ on heating give anhydrous $MgCl_2$. **[1982 - 1 Mark]**

6 MCQs with One or More than One Correct Answer

11. $MgSO_4$ on reaction with NH_4OH and Na_2HPO_4 forms a white crystalline precipitate. What is its formula? **[2006 - 5M, –1]**

(a) $Mg(NH_4)PO_4$ (b) $Mg_3(PO_4)_2$
(c) $MgCl_2.MgSO_4$ (d) $MgSO_4$

12. The species that do not contain peroxide ions are **[1992 - 1 Mark]**

(a) PbO_2 (b) H_2O_2 (c) SrO_2 (d) BaO_2

10 Subjective Problems

13. Give reason of the following:
$BeCl_2$ can be easily hydrolysed. **[1999 - 2 Marks]**

14. Work out the following using chemical equation:
Chlorination of calcium hydroxide produces bleaching powder. **[1998 - 2 Marks]**

15. Arrange the following sulphates of alkaline earth metals in order of decreasing thermal stability : $BeSO_4$, $MgSO_4$, $CaSO_4$, $SrSO_4$ **[1997 - 1 Mark]**

16. The crystalline salts of alkaline earth metals contain more water of crystallisation than the corresponding alkali metal salts. **[1997 - 2 Marks]**

17. Element *A* burns in nitrogen to give an ionic compound *B*. Compound *B* reacts with water to give *C* and *D*. A solution of *C* becomes 'milky' on bubbling carbon dioxide. Identify *A*, *B*, *C* and *D*. **[1997 - 3 Marks]**

18. Mg_3N_2 when reacted with water gives off NH_3 but HCl is not obtained from $MgCl_2$ on reaction with water at room temperature. **[1995 - 2 Marks]**

19. Complete and balance the following reactions :

$$Ca_5(PO_4)_3F + H_2SO_4 + H_2O \xrightarrow{\text{Heat}} \ldots\ldots + 5CaSO_4.2H_2O + \ldots\ldots$$ **[1994-1 Mark]**

20. Give briefly the isolation of magnesium from sea water by the Dow process. Give equations for the steps involved. **[1993 - 3 Marks]**

21. Write down the balanced equations for the reactions when: Carbon dioxide is passed through a suspension of lime stone in water. **[1991 - 1 Mark]**

Answer Key

Topic-1 : Group-1 Elements (Alkali Metals)

1. (b) **2.** (a) **3.** (b) **4.** (d) **5.** (Hydrogen, anode) **6.** (of solvated electrons)
7. (False) **8.** (True) **9.** (a, b) **10.** (a, b) **11.** (b)

Topic-2 : Group-2 Elements (Alkaline Earth Metals)

1. (a) **2.** (b) **3.** (b) **4.** (d) **5.** (a) **6.** (c) **7.** (b) **8.** (higher effective nuclear charge)
9. (Anhydrous HCl) **10.** (False) **11.** (a) **12.** (a)

Hints & Solutions

Topic-1: Group-1 Elements (Alkali Metals)

1. **(b)** When light falls on sodium surface, valence e^- gets excited and then returns back. The emission of photons creates a metallic lustre on the surface.
2. **(a)** Acidic and basic salts cannot exist together.
   Since $NaHCO_3$ is an acid salt of H_2CO_3, it reacts with NaOH to form Na_2CO_3 and H_2O.
   $NaHCO_3 + NaOH \rightarrow Na_2CO_3 + H_2O$
3. **(b)** $Na_2O_2 + H_2SO_4\,(20\%\text{ ice cold}) \longrightarrow Na_2SO_4 + H_2O_2$
4. **(d)** The free ammoniated electrons make the solution of Na in liquid NH_3 a very powerful reducing agent.
   The ammonical solution of an alkali metal is rather favoured as a reducing agent than its aqueous solution because in aqueous solution the alkali metal being highly electropositive evolves hydrogen from water (thus H_2O acts as an oxidisng agent) while its solution in ammonia is quite stable, provided no catalyst (transition metal) is present.
5. **Hydrogen, anode.**

$$NaH \xrightarrow{\text{electricity}} \underset{\downarrow +e^-}{\overset{\text{cathode}}{Na^+}} + \underset{\downarrow -2e^-}{\overset{\text{anode}}{2H^+}}$$
$$Na \qquad H_2$$

6. **of solvated electrons.**
7. **False :** Sodium when burnt in excess of oxygen gives sodium peroxide (Na_2O_2) and not sodium oxide.
   $4Na + O_2\,(\text{limited}) \rightarrow 2Na_2O$; $2Na + O_2(\text{excess}) \rightarrow Na_2O_2$
8. **True :** The metallic bonding decreases with increase in atomic size and thus, the tendency to show metallic bonding among alkali metals decreases from Li to Cs. Close packing of atoms in crystal lattice decreases from Li to Cs, resulting in an increase in softness.
9. **(a, b)** $4Na + O_2\,(\text{limited}) \xrightarrow{\Delta} 2Na_2O$

   $2Na + O_2\,(\text{excess}) \xrightarrow{\Delta} Na_2O_2$
10. **(a, b)** Blue colour is due to the presence of solvated (ammoniated) electrons, while electrical conductance is due to the presence of ions.

$$M \longrightarrow M^+ + e^-$$
$$M^+ + xNH_3 \longrightarrow [M(NH_3)_x]^+$$
$$e^- + yNH_3 \longrightarrow [e(NH_3)_y]^-$$

on adding

$$M + (x+y)NH_3 \longrightarrow \underset{\text{Ammoniated cation}}{[M(NH_3)_x]^+} + \underset{\text{Ammoniated electron}}{[e(NH_3)_y]^-}$$

Note: Sodium in liquid ammonia forms $NaNH_2$ only in presence of a catalyst like Pt black, iron oxide, etc.

$$[e(NH_3)_y]^- \xrightarrow{Fe_2O_3} NH_2^- + H_2 + (y-1)NH_3\,.$$

11. **(b)** Statement-1 is correct. Statement-2 is also correct but not the correct explanation becuase blue colour of the solution is due to the solvated electrons.
12. LiF has more ionic character while LiI has more covalent character. The latter is due to the greater polarizability of larger iodide ion than that of fluoride ion.
13. *(iv)* $2K_3[Fe(CN)_6] + H_2O_2 + 2KOH \rightarrow 2K_4[Fe(CN)_6] + 2H_2O + O_2$
    (iii) $NaCl + NH_4OH + CO_2 \rightarrow NH_4Cl + NaHCO_3$
14. Potassium carbonate cannot be manufactured by Solvay process, since, unlike sodium hydrogen carbonate, potassium hydrogen carbonate is rather too soluble in water to be precipitated like $NaHCO_3$.

Topic-2: Group-2 Elements (Alkaline Earth Metals)

1. **(a)** $MgCl_2 + 2NaHCO_3 \longrightarrow \underset{\text{(soluble)}}{MgHCO_3} + 2NaCl$

   $MgHCO_3 \xrightarrow{\text{heat}} MgCO_3 \downarrow + H_2O + CO_2$
2. **(b)** In going from top to bottom in a group, the first ionization potential decreases, thus
   $Be > Mg > Ca$
3. **(b)** The increasing thermal stability is
   $\underset{\text{(IV)}}{BeCO_3} < \underset{\text{(II)}}{MgCO_3} < \underset{\text{(III)}}{CaCO_3} < \underset{\text{(I)}}{K_2CO_3}$
   Increasing size of cation decreases its polarization ability towards carbonate, making the compound more stable.
4. **(d)** Glauber's salt is $Na_2SO_4 \cdot 10\,H_2O$.
5. **(a)** Ca is obtained by electrolysis of molten mixture of $CaCl_2$ mixed with CaF_2.

6. **(c)** Peroxide can produce hydrogen peroxide

$$BaO_2 \cdot 8H_2O + H_2SO_4 \longrightarrow BaSO_4 + H_2O_2 + 8H_2O$$

7. **(b)** $CaO + H_2O \xrightarrow{\text{Hissing sound}} Ca(OH)_2 + \text{Heat}$

$$CaO + CO_2 \longrightarrow CaCO_3$$

8. **higher effective nuclear charge.**

9. **Anhydrous HCl**

$\because$ All the water of crystallisation cannot be removed by heating hydrated $MgCl_2$. HCl checks the hydrolysis of $MgCl_2$ by its own water of crystalization.

10. **False :** Although 4 molecules of water of crystallisation are removed by heating, the remaining two react with $MgCl_2$ as per the equation given below :

$$MgCl_2 + 2H_2O \rightarrow MgO + 2HCl + H_2O$$

In order to avoid this to happen, $MgCl_2.2H_2O$ is dehydrated in presence of HCl gas, which checks, (being in excess) the hydrolysis of $MgCl_2$ by its own water of crystallisation.

11. **(a)** $Mg^{2+} + NH_3 + HPO_4^{2-} \longrightarrow Mg(NH_4)PO_4$

12. **(a)** H_2O_2 (hydrogen peroxide); SrO_2 and BaO_2 (Barium peroxide) contain peroxide ions $\left(O_2^{2-}\right)$.

13. $BeCl_2$ is hydrolysed due to high polarising power and presence of vacant *p*-orbitals in Be-atom.

$$(Be = 1s^2, 2s^2 2p_x^0\ 2p_y^0\ 2p_z^0)$$

14. $3Ca(OH)_2 + 2Cl_2 \rightarrow \underset{\substack{\text{Bleaching powder}\\ \text{(a mixture of } Ca(OCl)_2 \text{ and basic chloride)}}}{Ca(OCl)_2 \cdot Ca(OH)_2 \cdot CaCl_2 \cdot 2H_2O}$

15. $SrSO_4 > CaSO_4 > MgSO_4 > BeSO_4$ (Based upon size of cation or ionic character)

16. Smaller the size of cation, higher will be hydration tendency because **hydration energy of cation is inversely proportional to size of cation.**

The size of alkaline earth metal ions are smaller than the size of alkali metal ions. So, in crystalline form, the salts of alkaline earth metals have more water molecules than those of alkali metals.

17. $\underset{'A'}{3M} + N_2 \rightarrow \underset{'B'}{M_3N_2}$

$$\underset{'B'}{M_3N_2} + 6H_2O \rightarrow \underset{'C'}{3M(OH)_2} + \underset{'D'}{2NH_3}$$

$$\underset{'C'}{M(OH)_2} + CO_2 \rightarrow \underset{'D'}{MCO_3} + H_2O$$

M may be either Ca or Ba.

It is not magnesium because $Mg(OH)_2$ has very low solubility in water.

If we consider Ba as *M* then *A* is **Ba**, *B* is $\mathbf{Ba_3N_2}$, *C* is $\mathbf{Ba(OH)_2}$, *D* is $\mathbf{BaCO_3}$.

18. N^{3-} being smaller in size and high charge present on it make it more susceptible to hydrolysis :

$$N^{3-} + 3H_2O \rightarrow NH_3 + 3OH^-$$

Cl^- being a weak conjugate base does not undergo hydrolysis.

Mg^{2+} get hydrolysed as :

$$Mg^{2+} + 2H_2O \rightleftharpoons Mg(OH)_2 + 2H^+$$

19. $Ca_5(PO_4)_3F + 5H_2SO_4 + 10H_2O \xrightarrow{\Delta} 3H_3PO_4 + 5CaSO_4 \cdot 2H_2O + HF$

20. In sea water, Mg exists as $MgCl_2$.

On treating sea water with slaked lime, $Mg(OH)_2$ is obtained.

$$\underset{\text{in sea water}}{MgCl_2} + \underset{\text{slaked lime}}{Ca(OH)_2} \rightarrow Mg(OH)_2\downarrow + CaCl_2$$

On reacting $Mg(OH)_2$ with HCl, $MgCl_2$ is obtained.

$$Mg(OH)_2 + 2HCl \rightarrow MgCl_2 + H_2O$$

From $MgCl_2$, Mg is obtained by reduction of $MgCl_2$ with CaC_2.

$$MgCl_2 + CaC_2 \rightarrow Mg + CaCl_2 + 2C$$

21. $CaCO_3 + CO_2 + H_2O \rightarrow \underset{\text{Calcium bicarbonate}}{Ca(HCO_3)_2}$

Suspension of lime stone is $CaCO_3$.