

CHAPTER

8

The s-Block Elements

Section-A

JEE Advanced/ IIT-JEE

A Fill in the Blanks

1. Anhydrous MgCl_2 is obtained by heating hydrated salt with (1980)
2. The absorption of hydrogen by palladium is commonly known as (1983 - 1 Mark)
3. Sodium dissolved in liquid ammonia conducts electricity because (1985 - 1 Mark)
4. The electrolysis of molten sodium hydride liberates gas at the (1989 - 1 Mark)
5. Ca^{2+} has a smaller ionic radius than K^+ because it has (1993 - 1 Mark)

B True / False

1. $\text{MgCl}_2 \cdot 6\text{H}_2\text{O}$ on heating give anhydrous MgCl_2 . (1982 - 1 Mark)
2. The softness of group I-A metals increases down the group with increasing atomic number. (1986 - 1 Mark)
3. Sodium when burnt in excess of oxygen gives sodium oxide. (1987 - 1 Mark)

C MCQs with One Correct Answer

1. 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
2. HCl is added to following oxides. Which one would give H_2O_2 ? (1980)
 - (a) MnO_2
 - (b) PbO_2
 - (c) $\text{BaO}_2 \cdot 8\text{H}_2\text{O}$
 - (d) NO_2
3. 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.
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

5. Heavy water is (1983 - 1 Mark)
 - (a) H_2^{18}O
 - (b) water obtained by repeated distillation
 - (c) D_2O
 - (d) water at 4°C
6. The hydration energy of Mg^{++} is larger than that of:
 - (a) Al^{3+}
 - (b) Na^+ (1984 - 1 Mark)
 - (c) Be^{++}
 - (d) Mg^{3+}
7. 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
8. Molecular formula of Glauber's salt is: (1985 - 1 Mark)
 - (a) $\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$
 - (b) $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$
 - (c) $\text{FeSO}_4 \cdot 7\text{H}_2\text{O}$
 - (d) $\text{Na}_2\text{SO}_4 \cdot 10\text{H}_2\text{O}$
9. Hydrogen gas will not reduce: (1985 - 1 Mark)
 - (a) heated cupric oxide
 - (b) heated ferric oxide
 - (c) heated stannic oxide
 - (d) heated aluminium oxide
10. 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
11. 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
12. The volume strength of 1.5 N H_2O_2 solution is
 - (a) 4.8
 - (b) 8.4 (1991 - 1 Mark)
 - (c) 3.0
 - (d) 8.0
13. 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) $\text{I} < \text{II} < \text{III} < \text{IV}$
 - (b) $\text{IV} < \text{II} < \text{III} < \text{I}$
 - (c) $\text{IV} < \text{II} < \text{I} < \text{III}$
 - (d) $\text{II} < \text{IV} < \text{III} < \text{I}$
14. The set representing the correct order of first ionization potential is (2001S)
 - (a) $\text{K} > \text{Na} > \text{Li}$
 - (b) $\text{Be} > \text{Mg} > \text{Ca}$
 - (c) $\text{B} > \text{C} > \text{N}$
 - (d) $\text{Ge} > \text{Si} > \text{C}$

15. A sodium salt on treatment with MgCl_2 gives white precipitate only on heating. The anion of the sodium salt is
 (a) HCO_3^- (b) CO_3^{2-} (2004S)
 (c) NO_3^- (d) SO_4^{2-}
16. Hydrogen peroxide in its reaction with KIO_4 and NH_2OH respectively, is acting as a (JEE Adv. 2014)
 (a) Reducing agent, oxidising agent
 (b) Reducing agent, reducing agent
 (c) Oxidising agent, oxidising agent
 (d) Oxidising agent, reducing agent

D MCQs with One or More Than One Correct

- When zeolite, which is hydrated sodium aluminium silicate, is treated with hard water the sodium ions are exchanged with (1990 - 1 Mark)
 (a) H^+ ions (b) Ca^{++} ions
 (c) SO_4^{--} ions (d) Mg^{++} ions
 (e) OH^- ions
- 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
- Highly pure dilute solution of sodium in liquid ammonia (1998 - 2 Marks)
 (a) shows blue colour
 (b) exhibits electrical conductivity
 (c) produces sodium amide
 (d) produces hydrogen gas.
- The species present in solution when CO_2 is dissolved in water are (2006 - 5M, -1)
 (a) $\text{CO}_2, \text{H}_2\text{CO}_3, \text{HCO}_3^-, \text{CO}_3^{2-}$
 (b) $\text{H}_2\text{CO}_3, \text{CO}_3^{2-}$
 (c) $\text{CO}_3^{2-}, \text{HCO}_3^-$
 (d) $\text{CO}_2, \text{H}_2\text{CO}_3$
- MgSO_4 on reaction with NH_4OH and Na_2HPO_4 forms a white crystalline precipitate. What is its formula? (2006 - 5M, -1)
 (a) $\text{Mg}(\text{NH}_4)\text{PO}_4$ (b) $\text{Mg}_3(\text{PO}_4)_2$
 (c) $\text{MgCl}_2 \cdot \text{MgSO}_4$ (d) MgSO_4
- 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
- The reagent(s) used for softening the temporary hardness of water is (are) (2010)
 (a) $\text{Ca}_3(\text{PO}_4)_2$ (b) $\text{Ca}(\text{OH})_2$
 (c) Na_2CO_3 (d) NaOCl
- Hydrogen peroxide is a better oxidising agent than water. (1986 - 1 Mark)
- Magnesium oxide is used for the lining of steel making furnace. (1987 - 1 Mark)
- Why is sodium chloride added during electrolysis of fused anhydrous magnesium chloride? (1987 - 1 Mark)
- Hydrogen peroxide acts as an oxidising as well as a reducing agent. (1992 - 1 Mark)
- The crystalline salts of alkaline earth metals contain more water of crystallisation than the corresponding alkali metal salts. (1997 - 2 Marks)
- BeCl_2 can be easily hydrolysed. (1999 - 2 Marks)
- How will you prepare bleaching powder from slaked lime (1982 - 1 Mark)
- Write down the balanced equations for the reactions when:
 (i) Calcum phosphate is heated with a mixture of sand and carbon; (1985 - 1 Mark)
 (ii) An alkaline solution of potassium ferricyanide is reacted with hydrogen peroxide. (1982 - 1 Mark)
 (iii) Carbon dioxide is passed through a concentrated aqueous solution of sodium chloride saturated with ammonia. (1988 - 1 Mark)
 (iv) Potassium ferricyanide reacts with hydrogen peroxide in basic solution. (1989 - 1 Mark)
 (v) Carbon dioxide is passed through a suspension of lime stone in water. (1991 - 1 Mark)
- Give briefly the isolation of magnesium from sea water by the Dow process. Give equations for the steps involved. (1993 - 3 Marks)
- Complete and balance the following reactions :
 $\text{Ca}_5(\text{PO}_4)_3\text{F} + \text{H}_2\text{SO}_4 + \text{H}_2\text{O}$
 $\xrightarrow{\text{Heat}} \dots\dots\dots + 5\text{CaSO}_4 \cdot 2\text{H}_2\text{O} + \dots\dots\dots$ (1994 - 1 Mark)
- A 5.0 cm³ solution of H_2O_2 liberates 0.508 g of iodine from an acidified KI solution. Calculate the strength of H_2O_2 solution in terms of volume strength at STP. (1995 - 2 Marks)
- Explain the difference in the nature of bonding in LiF and LiI. (1996 - 2 Marks)
- To a 25ml H_2O_2 solution, excess of acidified solution of potassium iodide was added. The iodine liberated required 20 ml of 0.3 N sodium thiosulphate solution. Calculate the volume strength of H_2O_2 solution. (1997 - 5 Marks)
- Give reactions for the oxidation of hydrogen peroxide with potassium permanganate in acidic medium. (1997 - 1 Mark)

E Subjective Problems

- Give reasons for the following :
 (i) Sodium carbonate is made by Solvay process but the same process is not extended to the manufacture of potassium carbonate. (1981 - 1 Mark)
- 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)

11. 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)
12. Work out the following using chemical equation:
Chlorination of calcium hydroxide produces bleaching powder. (1998 - 2 Marks)
13. Hydrogen peroxide acts both as an oxidising and as a reducing agent in alkaline solution towards certain first row transition metal ions. Illustrate both these properties of H_2O_2 using chemical equations. (1998 - 4 Marks)

H Assertion & Reason Type Questions

1. Read the following statement and explanation and answer as per the options given below :

Statement : The alkali metals can form ionic hydrides which contain the hydride ion H^- .

Explanation : The alkali metals have low electronegativity; their hydrides conduct electricity when fused and liberate hydrogen at the anode. (1994 - 2 Marks)

- (a) Both S and E are true and E is the correct explanation of S.
 - (b) Both S and E are true but E is not the correct explanation of S.
 - (c) S is true but E is false.
 - (d) S is false but E is true
2. This question contains STATEMENT-1 (Assertion) and STATEMENT-2 (Reason) and has 4 choices (a), (b), (c) and (d) out of which ONLY ONE is correct. (2007)
- STATEMENT-1 :** Alkali metals dissolve in liquid ammonia to give blue solutions. because
- STATEMENT-2 :** Alkali metals in liquid ammonia give solvated species of the type $[\text{M}(\text{NH}_3)_n]^+$ (M = alkali metals).
- (a) Statement-1 is True, Statement-2 is True; Statement-2 is a correct explanation for Statement-1
 - (b) Statement-1 is True, Statement-2 is True; Statement-2 is not correct explanation for Statement-1
 - (c) Statement-1 is True, Statement-2 is False
 - (d) Statement-1 is False, Statement-2 is True.

Section-B JEE Main / AIEEE

1. KO_2 (potassium super oxide) is used in oxygen cylinders in space and submarines because it [2002]
 - (a) absorbs CO_2 and increases O_2 content
 - (b) eliminates moisture
 - (c) absorbs CO_2
 - (d) produces ozone.
2. The metallic sodium dissolves in liquid ammonia to form a deep blue coloured solution. The deep blue colour is due to formation of: [2002]
 - (a) solvated electron, $e(\text{NH}_3)_x^-$
 - (b) solvated atomic sodium, $\text{Na}(\text{NH}_3)_y$
 - (c) $(\text{Na}^+ + \text{Na}^-)$
 - (d) $\text{NaNH}_2 + \text{H}_2$
3. A metal M readily forms its sulphate MSO_4 which is water-soluble. It forms its oxide MO which becomes inert on heating. It forms an insoluble hydroxide $\text{M}(\text{OH})_2$ which is soluble in NaOH solution. Then M is [2002]
 - (a) Mg
 - (b) Ba
 - (c) Ca
 - (d) Be.
4. In curing cement plasters water is sprinkled from time to time. This helps in [2003]
 - (a) developing interlocking needle-like crystals of hydrated silicates
 - (b) hydrating sand and gravel mixed with cement
 - (c) converting sand into silicic acid
 - (d) keeping it cool
5. The substance **not** likely to contain CaCO_3 is
 - (a) calcined gypsum
 - (b) sea shells
 - (c) dolomite
 - (d) a marble statue [2003]
6. The solubilities of carbonates decrease down the magnesium group due to a decrease in [2003]
 - (a) hydration energies of cations
 - (b) inter-ionic attraction
 - (c) entropy of solution formation
 - (d) lattice energies of solids
7. Which one of the following processes will produce hard water ? [2003]
 - (a) Saturation of water with MgCO_3
 - (b) Saturation of water with CaSO_4
 - (c) Addition of Na_2SO_4 to water
 - (d) Saturation of water with CaCO_3
8. One mole of magnesium nitride on the reaction with an excess of water gives : [2004]
 - (a) two moles of ammonia
 - (b) one mole of nitric acid
 - (c) one mole of ammonia
 - (d) two moles of nitric acid
9. Which of the following species is diamagnetic in nature?
 - (a) H_2^-
 - (b) H_2^+
 - (c) H_2
 - (d) He_2^+ [2005]

10. Based on lattice energy and other considerations which one of the following alkali metal chlorides is expected to have the highest melting point ? [2005]
 (a) RbCl (b) KCl
 (c) NaCl (d) LiCl
11. Which of the following statements in relation to the hydrogen atom is correct ? [2005]
 (a) 3s, 3p and 3d orbitals all have the same energy
 (b) 3s and 3p orbitals are of lower energy than 3d orbital
 (c) 3p orbital is lower in energy than 3d orbital
 (d) 3s orbital is lower in energy than 3p orbital
12. The ionic mobility of alkali metal ions in aqueous solution is maximum for [2006]
 (a) Li^+ (b) Na^+
 (c) K^+ (d) Rb^+
13. In context with the industrial preparation of hydrogen from water gas ($\text{CO} + \text{H}_2$), which of the following is the correct statement? [2008]
 (a) CO and H_2 are fractionally separated using differences in their densities
 (b) CO is removed by absorption in aqueous Cu_2Cl_2 solution
 (c) H_2 is removed through occlusion with Pd
 (d) CO is oxidised to CO_2 with steam in the presence of a catalyst followed by absorption of CO_2 in alkali
14. Which of the following on thermal decomposition yields a basic as well as acidic oxide ? [2012]
 (a) NaNO_3 (b) KClO_3
 (c) CaCO_3 (d) NH_4NO_3
15. Very pure hydrogen (99.9) can be made by which of the following processes ? [2012]
 (a) Reaction of methane with steam
 (b) Mixing natural hydrocarbons of high molecular weight
 (c) Electrolysis of water
 (d) Reaction of salts like hydrides with water
16. In which of the following reactions H_2O_2 acts as a reducing agent? [JEE M 2014]
 (a) $\text{H}_2\text{O}_2 + 2\text{H}^+ + 2\text{e}^- \rightarrow 2\text{H}_2\text{O}$
 (b) $\text{H}_2\text{O}_2 + 2\text{e}^- \rightarrow \text{O}_2 + 2\text{H}^+$
 (c) $\text{H}_2\text{O}_2 + 2\text{e}^- \rightarrow 2\text{OH}^-$
 (d) $\text{H}_2\text{O}_2 + 2\text{OH}^- - 2\text{e}^- \rightarrow \text{O}_2 + 2\text{H}_2\text{O}$
17. Which one of the following alkaline earth metal sulphates has its hydration enthalpy greater than its lattice enthalpy ? [JEE M 2015]
 (a) BaSO_4 (b) SrSO_4
 (c) CaSO_4 (d) BeSO_4
18. The molecular formula of a commercial resin used for exchanging ions in water softening is $\text{C}_8\text{H}_7\text{SO}_3^- \text{Na}^+$ (Mol. wt. 206). What would be the maximum uptake of Ca^{2+} ions by the resin when expressed in mole per gram resin ? [JEE M 2015]
 (a) $\frac{2}{309}$ (b) $\frac{1}{412}$
 (c) $\frac{1}{103}$ (d) $\frac{1}{206}$
19. From the following statements regarding H_2O_2 , choose the incorrect statement : [JEE M 2015]
 (a) It has to be stored in plastic or wax lined glass bottles in dark
 (b) It has to be kept away from dust
 (c) It can act only as an oxidizing agent
 (d) It decomposes on exposure to light
20. Which one of the following statements about water is FALSE? [JEE M 2016]
 (a) There is extensive intramolecular hydrogen bonding in the condensed phase.
 (b) Ice formed by heavy water sinks in normal water.
 (c) Water is oxidized to oxygen during photosynthesis.
 (d) Water can act both as an acid and as a base.
21. Which of the following atoms has the highest first ionization energy? [JEE M 2016]
 (a) K (b) Sc
 (c) Rb (d) Na
22. The main oxides formed on combustion of Li, Na and K in excess of air are, respectively: [JEE M 2016]
 (a) Li_2O_2 , Na_2O_2 and KO_2 (b) Li_2O , Na_2O_2 and KO_2
 (c) Li_2O , Na_2O and KO_2 (d) LiO_2 , Na_2O_2 and K_2O

Section-A : JEE Advanced/ IIT-JEE

- A** 1. Anhydrous HCl 2. occlusion 3. of solvated electrons
4. Hydrogen, anode 5. higher effective nuclear charge
- B** 1. F 2. T 3. F
- C** 1. (b) 2. (c) 3. (a) 4. (d) 5. (c) 6. (b) 7. (b)
8. (d) 9. (d) 10. (a) 11. (b) 12. (b) 13. (b) 14. (b)
15. (a) 16. (a)
- D** 1. (b, d) 2. (a, c) 3. (a, b) 4. (a) 5. (a) 6. (a, b) 7. (b, c, d)
- E** 6. 4.48 volumes 8. 1.344
10. Ba, Ba₃N₂, Ba(OH)₂, BaCO₃ 11. SrSO₄ > CaSO₄ > MgSO₄ > BeSO₄
- H** 1. (a) 2. (b)

Section-B : JEE Main/ AIEEE

1. (a) 2. (a) 3. (d) 4. (a) 5. (a) 6. (a) 7. (b)
8. (a) 9. (c) 10. (c) 11. (a) 12. (d) 13. (d) 14. (c)
15. (d) 16. (d) 17. (d) 18. (b) 19. (c) 20. (a) 21. (b)
22. (b)

Section-A JEE Advanced/ IIT-JEE

A. Fill in the Blanks

1. **Anhydrous HCl**
∴ All the water of crystallisation cannot be removed by heating hydrated MgCl₂.
2. **occlusion.**
3. **of solvated electrons.**
4. **Hydrogen, anode.**
- $$\text{NaH} \xrightarrow{\text{electricity}} \begin{array}{ccc} \text{cathode} & & \text{anode} \\ \text{Na}^+ + 2\text{H}^+ & & \\ \downarrow +e^- & & \downarrow -2e^- \\ \text{Na} & & \text{H}_2 \end{array}$$
5. **higher effective nuclear charge.**

B. True/False

1. **False** : Although 4 molecules of water of crystallisation are removed by heating, the remaining two react with MgCl₂ as per the equation given below :
 $\text{MgCl}_2 + 2\text{H}_2\text{O} \rightarrow \text{MgO} + 2\text{HCl} + \text{H}_2\text{O}$
NOTE : In order to avoid this to happen, MgCl₂·2H₂O is dehydrated in presence of HCl gas, which checks, (being in excess) the hydrolysis of MgCl₂ by its own water of crystallisation.

2. **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 and thus close packing of atoms in crystal lattice decreases from Li to Cs resulting in an increase in softness.
3. **False** : Sodium when burnt in excess of oxygen gives monoxide and sodium peroxide (Na₂O₂) and not sodium oxide.
 $4\text{Na} + \text{O}_2 \rightarrow 2\text{Na}_2\text{O}$; $2\text{Na} + \text{O}_2 \rightarrow \text{Na}_2\text{O}_2$

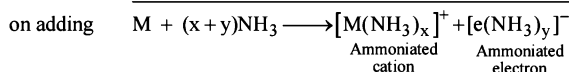
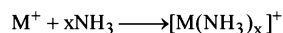
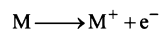
C. MCQs with One Correct Answer

1. (b) $\text{CaO} + \text{H}_2\text{O} \xrightarrow{\text{Hissing sound}} \text{Ca(OH)}_2 + \text{Heat}$
 $\text{CaO} + \text{CO}_2 \longrightarrow \text{CaCO}_3$
2. (c) $\text{BaO}_2 \cdot 8\text{H}_2\text{O} + \text{H}_2\text{SO}_4 \longrightarrow \text{BaSO}_4 + \text{H}_2\text{O}_2 + 8\text{H}_2\text{O}$
3. (a) Ca is obtained by electrolysis of molten mixture of CaCl₂ mixed with CaF₂.
4. (d) The free ammoniated electrons make the solution of Na in liquid NH₃ a very powerful reducing agent.
NOTE : 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 H₂O acts as an oxidising agent) while its solution in ammonia is quite stable, provided no catalyst (transition metal) is present.

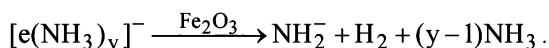
5. (c) Heavy water is D_2O , deuterium oxide.
6. (b) Na^+ ion has larger size than Mg^{2+} ion and hence hydration energy of Mg^{2+} is larger than that of Na^+ .
7. (b) $Na_2O_2 + H_2SO_4$ (20% ice cold) $\longrightarrow Na_2SO_4 + H_2O_2$
8. (d) Glauber's salt is $Na_2SO_4 \cdot 10H_2O$.
9. (d) **NOTE** : The more electropositive metal will not be reduced by hydrogen.
Among given choices only Al is more electropositive than hydrogen.
 $\therefore$ It will not be reduced by hydrogen.
10. (a) **NOTE** : 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 .
 $NaHCO_3 + NaOH \longrightarrow Na_2CO_3 + H_2O$
11. (b) Oscillation of loose electrons.
12. (b) Volume strength = Normality $\times 5.6 = 1.5 \times 5.6 = 8.4$ L
13. (b) The increasing thermal stability is
 $BeCO_3 < MgCO_3 < CaCO_3 < K_2CO_3$
(IV) (II) (III) (I)
NOTE : Increasing size of cation decreases its polarization ability towards carbonate, making the compound more stable.
14. (b) In going from top to bottom in a group, the first ionization potential decreases, thus
 $Be > Mg > Ca$
15. (a) $MgCl_2 + 2NaHCO_3 \longrightarrow MgHCO_3 + 2NaCl$
(soluble)
 $MgHCO_3 \xrightarrow{\text{heat}} MgCO_3 \downarrow + H_2O + CO_2$
16. (a) $KIO_4 + H_2O_2 \longrightarrow KIO_3 + H_2O + O_2$
Thus H_2O_2 is acting as a reducing agent
 $2NH_2OH + H_2O_2 \longrightarrow N_2 + 4H_2O$
Here H_2O_2 is acting as an oxidising agent

D. MCQs with One or More Than One Correct

1. (b,d) $Na_2Al_2Si_2O_8 \cdot xH_2O + Ca^{2+} \longrightarrow CaAl_2Si_2O_8 \cdot xH_2O + 2Na^+$
 $Na_2Al_2Si_2O_8 \cdot xH_2O + Mg^{2+} \longrightarrow MgAl_2Si_2O_8 \cdot xH_2O + 2Na^+$
2. (a, c) Only H_2O_2 (hydrogen peroxide) and BaO_2 (Barium peroxide) contain peroxide ions. So (a) and (c) are the correct choices.
3. (a, b) Blue colour is due to the presence of solvated (ammoniated) electrons, while electrical conductance is due to the presence of ions.



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

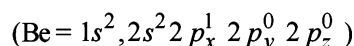


4. (a) $CO_2 + H_2O \rightleftharpoons H_2CO_3$
 $\rightleftharpoons H^+ + HCO_3^- \rightleftharpoons H^+ + CO_3^{2-}$

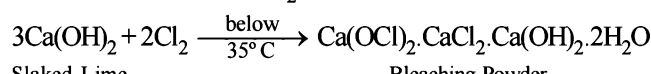
5. (a) $Mg^{2+} + NH_3 + HPO_4^{2-} \longrightarrow Mg(NH_4)PO_4$
6. (a,b) $4Na + O_2$ (limited) $\xrightarrow{\Delta} 2Na_2O$
 $2Na + O_2$ (excess) $\xrightarrow{\Delta} Na_2O_2$
7. (b,c,d) Temporary hardness is due to bicarbonates of calcium and magnesium. Temporary hardness can be removed by Clark's process, which involves the addition of slaked lime, $Ca(OH)_2$. Washing soda (Na_2CO_3) removes both the temporary and permanent hardness by converting soluble calcium and magnesium compounds into insoluble carbonates.
 $Ca(HCO_3)_2 + Ca(OH)_2 \longrightarrow 2CaCO_3 \downarrow + 2H_2O$
 $Ca(HCO_3)_2 + Na_2CO_3 \longrightarrow CaCO_3 \downarrow + 2NaHCO_3$
 $2OCl^- + 2H_2O \rightleftharpoons 2HOCl + 2OH^-$
 $Ca(HCO_3)_2 + 2OH^- \longrightarrow CaCO_3 \downarrow + CO_3^{2-} + 2H_2O$

E. Subjective Problems

1. (i) 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 $NaHCO_3$.
- (ii) H_2O_2 is a better oxidising agent than H_2O because oxidation number of oxygen in H_2O_2 is -1 and that in water it is -2 . So H_2O_2 easily reduces to -2 oxidation number.
- (iii) MgO is used for the lining of steel making furnace because it acts as basic flux and facilitates the removal of acidic impurities of Si, P and S from steel through slag formation.
- (iv) The anhydrous magnesium chloride is fused with $NaCl$ to provide conductivity to the electrolyte and to lower the fusion temperature of anhydrous $MgCl_2$.
NOTE : $NaCl$ prevents hydrolysis of $MgCl_2$.
- (v) The oxidation state of oxygen in H_2O_2 (i.e. -1) can be changed to 0 or -2 i.e. oxygen in H_2O_2 exists in an intermediate oxidation state with respect to O_2 and O^{2-} . Hence it acts both as an oxidising and reducing agent.
- (vi) **NOTE** : 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.
- (vii) $BeCl_2$ is hydrolysed due to high polarising power and presence of vacant p-orbitals in Be-atom.



2. Bleaching powder, $Ca(OCl)_2$, can be prepared by passing chlorine through $Ca(OH)_2$ solution.



Slaked Lime

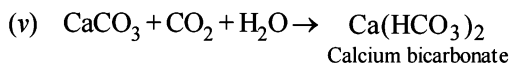
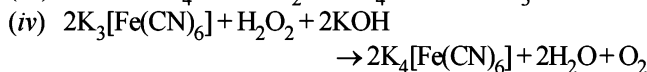
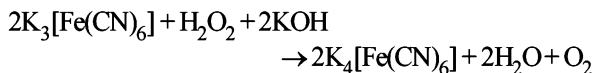
Bleaching Powder

(a mixture of $Ca(OCl)_2$ and basic chloride)



This is the **electrothermal process** to extract phosphorus from phosphorite or bone ash $[\text{Ca}_3(\text{PO}_4)_2]$.

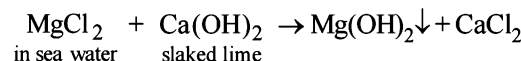
(ii) Ferricyanide is oxidised to ferrocyanide on treatment with alkali



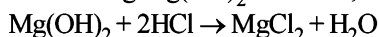
NOTE : Suspension of lime stone is CaCO_3 .

4. In sea water Mg exists as MgCl_2 .

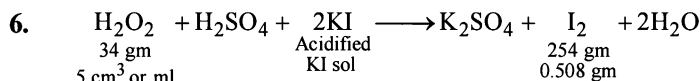
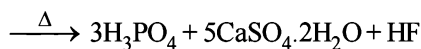
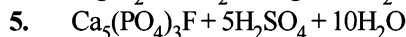
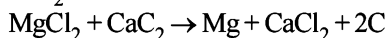
On treating sea water with slaked lime $\text{Mg}(\text{OH})_2$ is obtained.



On reacting $\text{Mg}(\text{OH})_2$ with HCl , MgCl_2 is obtained.



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



i.e. 254 gm of I_2 is released by 34 gm H_2O_2

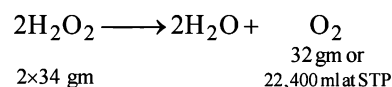
$\therefore$ 0.508 gm of I_2 will be released by

$$= \frac{34}{254} \times 0.508 = 0.068 \text{ gm}$$

5 ml of H_2O_2 sol. contains 0.068 gm of H_2O_2 .

$\therefore$ 1 ml of H_2O_2 sol contains $\frac{0.068}{5}$ gm H_2O_2

NOTE : The strength of H_2O_2 is generally calculated in terms of **volume strength**. According to which 10 volume of H_2O_2 means that 1 ml of H_2O_2 sol gives 10 ml of O_2 at STP.



i.e., 68 gm of H_2O_2 gives 22,400 ml of O_2 at STP
or 1 ml of H_2O_2 sol

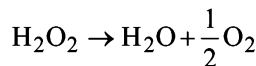
$$\text{or } \frac{0.068}{5} \text{ gm of } \text{H}_2\text{O}_2 \text{ gives } \frac{22,400}{68} \times \frac{0.068}{5} = 4.48 \text{ ml}$$

or 1 ml of H_2O_2 sol gives 4.48 ml of O_2 i.e. strength of H_2O_2 sol is **4.48 volumes**

7. LiF has more ionic character while LiI has more covalent character. The latter is due to the greater polarizability of larger iodide ion than the fluoride ion.

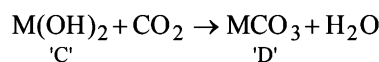
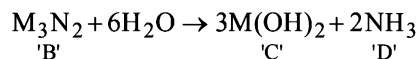
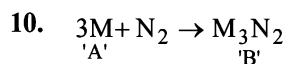
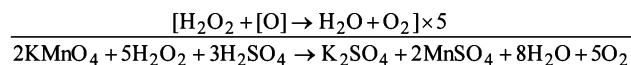
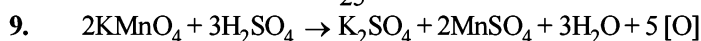
8. Meq. of H_2O_2 = Meq. of $\text{Na}_2\text{S}_2\text{O}_3$

$$\frac{w}{17} \times 1000 = 20 \times 0.3 \quad \therefore w = 0.102 \text{ g}$$



$$\therefore \text{Volume of } \text{O}_2 = \frac{11200 \times 0.102}{34} = 33.6 \text{ mL}$$

$$\therefore \text{Volume strength} = \frac{33.6}{25} = \mathbf{1.344}$$

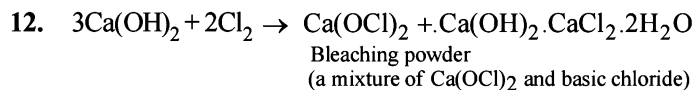


M may be either Ca or Ba.

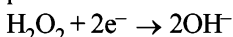
NOTE : It is not magnesium because $\text{Mg}(\text{OH})_2$ has very low solubility in water.

If we consider Ba as M then A is **Ba**, B is **Ba₃N₂**, C is **Ba(OH)₂**, D is **BaCO₃**.

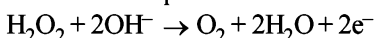
11. $\text{SrSO}_4 > \text{CaSO}_4 > \text{MgSO}_4 > \text{BeSO}_4$ (Based upon size of cation or ionic character)



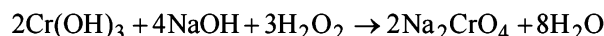
13. When H_2O_2 acts as oxidising agent, following reaction takes place:



While regarding its action as reducing agent, the following reaction takes place:

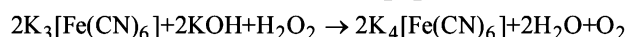


Examples of oxidising character of H_2O_2 in alkaline medium



Here Cr^{3+} (Cr is a first row transition metal) is oxidised to Cr^{6+} .

Example of reducing character of H_2O_2 in alkaline medium



Here Fe^{3+} (Fe is a first row transition metal) is reduced to Fe^{2+} .

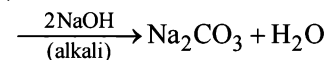
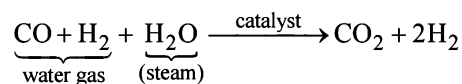
H. Assertion & Reason Type Questions

- (a) Both S & E are true and E is the correct explanation of S.
- (b) Statement-1 is correct. Statement-2 is also correct but not the correct explanation because blue colour of the solution is due to the solvated electrons.

Section-B

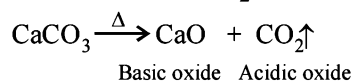
JEE Main/ AIEEE

- (a) $2\text{KO}_2 + 2\text{H}_2\text{O} \rightarrow 2\text{KOH} + \text{H}_2\text{O}_2 + \text{O}_2$.
 KO_2 is used as an oxidising agent. It is used as air purifier in space capsules. Submarines and breathing masks as it **produces oxygen and remove carbon dioxide**.
- (a) The alkali metals dissolve in liquid ammonia without evolution of hydrogen. The metal loses electrons and combine with ammonia molecule.
 $\text{M} \rightarrow \text{M}^+$ (in liquid ammonia) + e^- (ammoniated)
 $\text{M} + (x+y)\text{NH}_3 \rightarrow [\text{M}(\text{NH}_3)_x]^+ + e^-(\text{NH}_3)_y$
Solvated electron
 It is ammoniated electron which is responsible for colour.
- (d) Sulphate of alkaline earth metal are sparingly soluble or almost not soluble in water whereas BeSO_4 is soluble in water due to high degree of solvation. $\text{Be}(\text{OH})_2$ is insoluble in water but soluble in NaOH .
 $\text{BeO} + 2\text{NaOH} \rightarrow \text{Na}_2\text{BeO}_2 + \text{H}_2\text{O}$
- (a) Setting of cement is exothermic process which develops interlocking crystals of hydrated silicates
- (a) Gypsum is $\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$
- (a) As we move down the group, the lattice energies of carbonates remain approximately the same. However the hydration energies of the metal cation decreases from Be^{++} to Ba^{++} , hence the solubilities of carbonates of the alkaline earth metal decrease down the group mainly due to decreasing hydration energies of the cations from Be^{++} to Ba^{++} .
- (b) Permanent hardness of water is due to chlorides and sulphates of calcium and magnesium i.e. CaCl_2 , CaSO_4 , MgCl_2 and MgSO_4 .
- (a) $\text{Mg}_3\text{N}_2 + 6\text{H}_2\text{O} \rightleftharpoons 3\text{Mg}(\text{OH})_2 + 2\text{NH}_3$
- (c) **TIPS/Formulae :**
 A diamagnetic substance contains no unpaired electron.
 H_2 is diamagnetic as it contains all paired electrons
 $\text{H}_2 = \sigma_b^2$, $\text{H}_2^+ = \sigma_b^1$, $\text{H}_2^- = \sigma_b^2$,
 (diamagnetic) (paramagnetic) (paramagnetic)
 $\sigma_a^{*1}; \text{He}_2^+ = \sigma_b^2, \sigma_a^{*1}$
 (paramagnetic) (paramagnetic)
- (c) LiCl has partly covalent character. Other halides are ionic in nature. Lattice energy decreases with increase of ionic radius of cation, anion being the same. Larger is the lattice energy, the higher will be m. pt. hence NaCl will have highest lattice energy.
- (a) **NOTE :** In one electron species, such as H-atom, the energy of orbital depends only on the principal quantum number, n.
 Hence answer (d)
 i.e. $s < 2s = 2p < 3s = 3p = 3d < 4s = 4p \Rightarrow 4d = 4g$
- (d) Smaller the size of cation higher is its hydration energy and greater is its ionic mobility hence the correct order is $\text{Li}^+ < \text{Na}^+ < \text{K}^+ < \text{Rb}^+$
- (d) On the industrial scale hydrogen is prepared from water gas according to following reaction sequence

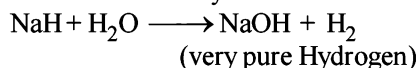


From the above it is clear that CO is first oxidised to CO_2 which is then absorbed in NaOH .

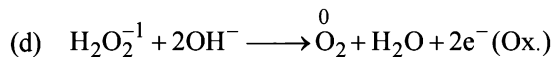
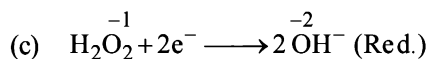
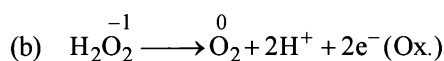
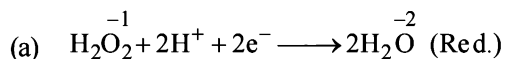
- (c) Calcium carbonate on thermal decomposition gives CaO (Basic oxide) and CO_2 (Acidic oxide)



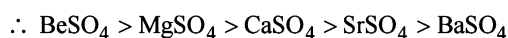
- (d) Very pure hydrogen can be prepared by the action of water on sodium hydride.



- (d) The reducing agent loses electron during redox reaction i.e. oxidises itself.



- (d) In alkaline earth metals, ionic size increases down the group. The lattice energy remains constant because sulphate ion is so large, so that small change in cationic size does not make any difference. On moving down the group the degree of hydration of metal ions decreases very much leading to decrease in solubility.



- (b) 2 mole of water softner require 1 mole of Ca^{2+} ion

So, 1 mole of water softner require $\frac{1}{2}$ mole of Ca^{2+} ion

Thus, $\frac{1}{2 \times 206} = \frac{1}{412} \text{ mol/g}$ will be maximum uptake

- (c) H_2O_2 has oxidizing and reducing properties both.
- (a) There is extensive intermolecular hydrogen bonding in the condensed phase instead of intramolecular H-bonding.
- (b) Alkali metals have the lowest ionization energy in each period on the other hand Sc is a d-block element. Transition metals have smaller atomic radii and higher nuclear charge leading to high ionisation energy.
- (b) On heating with excess of air Li, Na and K forms following oxides

