1 Preparation of Hydrogen

1. $Na/Ca + cold H_2O \longrightarrow NaOH + H_2$
2. $Se/Fe/Mn/Co/Ni/Cr \xrightarrow{Steam} H_2$
3. $CH_4 + H_2O \xrightarrow[1000^\circ C]{Ni} H_2$
4. $Zn/Sn/Pb/Si/Al \xrightarrow{NaOH} H_2$
5. $C + H_2O \xrightarrow[Ni]{\text{Bosch Process}} H_2$
6. $Fe \xrightarrow[H_2O]{\text{Lone's Process}} H_2$
7. $Zn/Mg/Fe \xrightarrow{Acid} H_2$
8. $NaH/LiH/CaH_2/NaBH_4 \xrightarrow{H_2O} H_2$
9. $Mg/Zn/Al \xrightarrow[H_2O]{Boil} H_2$

2 Properties of H_2O and D_2O

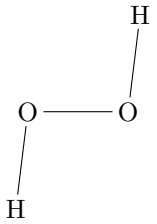
Properties	H_2O	D_2O
Melting Point	273.2 K	276.8 K
Boiling Point	373.2 K	374.4 K
Maximum Density (in gcm^{-3})	1.000	1.1073
Heat of Vaporization (in $KJmol^{-1}$)	40.66	41.61
Surface Tension	72	67.8
Dielectric Constant	78.39	78.06
Refractive Index	1.3333	1.3284
Viscosity (at 273 K)	10.87	14.2

3 H_2O_2

3.1 Preparation of H_2O_2

1. $Na_2O_2 + \xrightarrow{H_2SO_4(dil\cdot)} H_2O_2$
2. $BaO_2 \xrightarrow{H_2SO_4 or H_3PO_4} H_2O_2$
3. 2-Ethyl Anthraquinol $\xrightarrow{Air}$ H2O2
4. $BaO_2 \xrightarrow{CO + H_2O} H_2O_2$
5. $H_2S_2O_8 \xrightarrow{H_2O} H_2O_2$

3.2 Structure of H_2O_2: Open Book Structure



3.3 Properties of H_2O_2

1. As Reducing Agent:
   (a) $H_2O_2 \xrightarrow{K_2Cr_2O_7/H^+} Cr^{3+}$
   (b) $H_2O_2 \xrightarrow{K_2MnO_4/H^+} Mn^{2+}$
   (c) $H_2O_2 \xrightarrow{MnO_2/H^+} Mn^{2+}$
   (d) $H_2O_2 \xrightarrow{Ag_2O} Ag$
2. As Bleaching Agent: $H_2O_2 \longrightarrow H_2O + [O]$
3. As Oxidizing Agent:
   (a) $H_2O_2 \xrightarrow{K_2Cr_2O_7/H^+} CrO_5$
   (b) $H_2O_2 \xrightarrow{H_2S} H_2O + S$
   (c) $H_2O_2 \xrightarrow{Fe^{2+}} Fe^{3+}$
   (d) $H_2O_2 \xrightarrow{I^-} I_2$
   (e) $H_2O_2 \xrightarrow{NO_2^-} NO_3^-$
   (f) $H_2O_2 \xrightarrow{SO_3^{2-}} SO_4^{2-}$

4 Physical Properties of Alkali Metals

1. Atomic radii: Li < Na < K < Rb < Cs
2. Ionic radii:
   (a) Gas: $Li^+ < Na^+ < K^+ < Rb^+ < Cs^+$
   (b) In aqueous state: $Li^+_{(aq)} > Na^+_{(aq)} > K^+_{(aq)} > Rb^+_{(aq)} > Cs^+_{(aq)}$
3. Melting Point: Li > Na > K > Rb > Cs
4. Boiling Point: Li > Na > K > Rb > Cs

5. Density:* Li < Na < K < Rb < Cs
6. Specific Heat Capacity: Li > Na > K > Rb > Cs
7. Reducing Nature: Li > Cs > Rb ≈ K > Na
8. Flame Colour in Bunsen Burner:
   (a) Li: Crimson Red
   (b) Na: Golden Yellow
   (c) K: Pale Violet
   (d) Rb: Red Violet
   (e) Cs: Bluish

5 NaOH

5.1 Preparation

1. $NaCl \xrightarrow{\text{Electrolysis}} NaOH$

5.2 Properties

1. $NaOH \xrightarrow{B} Na_2BO_3$
2. $NaOH \xrightarrow{Si} Na_2SiO_3$
3. $NaOH \xrightarrow{Sn} Na_2SnO_3$
4. $NaOH \xrightarrow{Al_2O_3} NaAlO_2$
5. $NaOH \xrightarrow{PbO_2} Na_2PbO_3$
6. $NaOH \xrightarrow{ZnO} Na_2ZnO_2$
7. $NaOH \xrightarrow{CO + \Delta} HCOONa$
8. $NaOH \xrightarrow{S} Na_2S + H_2O + Na_2SO_3$
9. $NaOH \xrightarrow{NO_2} NaNO_2 + NaNO_3$
10. $NaOH \xrightarrow{P_4} NaH_2PO_3 + PH_3$
11. $NaOH \xrightarrow{SO_2} Na_2SO_3$
12. $NaOH \xrightarrow{CO_2} Na_2CO_3$
13. $NaOH \xrightarrow{coldX_2} X^- + XO^-$
14. $NaOH \xrightarrow{X_2 + \Delta} X^- + XO_3^-$

6 $NaCO_3 \cdot 10\,H_2O$

6.1 Preparation

1. Ammonical NaCl + $CaCO_3 \xrightarrow{\text{Solvay's Process}} NaCO_3 \cdot 10\,H_2O$

6.2 Properties

1. $NaCO_3 \cdot 10\,H_2O \xrightarrow{SO_2} Na_2SO_3$
2. $NaCO_3 \cdot 10\,H_2O \xrightarrow{CaCl_2} Na_2CO_3$
3. $NaCO_3 \cdot 10\,H_2O \xrightarrow{AgNO_3} AgCO_2$
4. $NaCO_3 \cdot 10\,H_2O \xrightarrow{CuSO_4} CuCO_3$
5. $NaCO_3 \cdot 10\,H_2O \xrightarrow{ZnSO_4} ZnCO_3 \cdot Zn(OH)_2$
6. $NaCO_3 \cdot 10\,H_2O \xrightarrow{SiO_2} Na_2SiO_3 + CO_2$
7. $NaCO_3 \cdot 10\,H_2O \xrightarrow{CO_2 + H_2O(\text{Excess})} \boxed{NaHCO_3}$

6.3 $NaHCO_3$

1. $NaHCO_3 \xrightarrow{\Delta} Na_2CO_3 + H_2O + CO_2$
2. $NaHCO_3 \xrightarrow{ZnSO_4} ZnCO_3$

7 NaCN

7.1 Preparation

1. $NaNH_2 \xrightarrow{\text{Coke} + \Delta} NaCN$
2. $NaOH \xrightarrow{HCN} NaCN$
3. $CaCN_2 \xrightarrow{Na_2CO_3 + \text{Coke}} NaCN$

7.2 Properties

1. $NaCN \xrightarrow{\text{Au} + \text{Air}} Na_2[Au(CN_4)]$
2. $NaCN \xrightarrow{FeSO_4} Na_4[Fe(CN)_6]$
3. $NaCN \xrightarrow{CuSO_4} Na_3[Cu(CN)_4]$

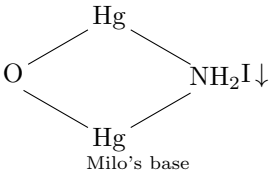
4. $NaCN \xrightarrow{CdSO_4} Na_2[Cd(CN)_4]$
5. $NaCN \xrightarrow{AgNO_3} Na[Ag(CN)_2]$

8 KI

8.1 Preparation

1. $KOH \xrightarrow{HI} KI$
2. $KOH \xrightarrow{I2} KI$

8.2 Properties

1. $KI \xrightarrow[H_2SO_4]{KMnO_4} K_2SO_4 + MnSO_4 + I_2 + H_2O$
2. $KI \xrightarrow{H_2SO_4} K_2SO_4 + I_2 + SO_2$
3. $KI \xrightarrow{CuSO_4} Cu_2I_2 + I_2$
4. $KI \xrightarrow{Pb(CH_3COO)_2} \underset{\text{Yellow}}{PbI_2\downarrow}$
5. $KI \xrightarrow{AgNO_3} \underset{\text{Yellow}}{AgI\downarrow}$
6. $KI \xrightarrow{K_2Cr_2O_7 + H_2SO_4} K_2SO_4 + Cr_2(SO_4)_3 + I_2 + H_2O$
7. $KI \xrightarrow{HgCl_2} HgI_2 \xrightarrow{HI} \underset{\text{Nessler's reagent}}{KHgI_4} \xrightarrow{NH_3 \text{or} NH_4^+}$ 

8. $KI \xrightarrow{H_2SO_4} K_2SO_4 \xrightarrow{Al_2(SO_4)_3} \underset{\text{Alum}}{K_2SO_4 \cdot Al_2(SO_4)_3 \cdot 24\,H_2O}$

   Note: General Formula of Alum: $M_2^{+}SO_4 \cdot M_2^{3+}(SO_4)_3 \cdot 24\,H_2O$

9 Physical Properties of Alkali Earth Metals

1. Atomic radii: Be < Mg < Ca < Sr < Ba
2. Melting Point: Be > Ca > Sr > Ba > Mg
3. Density: Ba > Sr > Be > Mg > Ca

4. Heat of Hydration (in $KJmol^{-1}$): Li > Na > K > Rb > Cs
5. Reducing Nature: Ba > Sr > Ca > Mg > Be
6. Flame Colour in Bunsen Burner:
   (a) Be: None
   (b) Mg: None
   (c) Ca: Brick Red
   (d) Sr: Crimson
   (e) Ba: Apple Green
   (f) Ra: Crimson

10 Preparation and properties of magnesium compounds

1. $\boxed{MgCl_2 \cdot 6\,H_{20}} \xrightarrow[NH_4Cl]{Na_2HPO_4} Mg(NH_4)PO_4 \xrightarrow{\Delta} Mg_2P_2O_7$
2. $MgCl_2 \cdot 6\,H_{20} \xrightarrow{DryHCl} MgCl_2 \xrightarrow{Electrolysis} Mg \xrightarrow{Air} Mg_3N_2 + MgO$
3. $MgCl_2 \cdot 6\,H_{20} \xrightarrow{NaHCO_3} MgCO_3 \xrightarrow{\Delta} Mg) + CO_2 \xrightarrow{HI} MgI_2 \cdot 5\,H_2O$
4. $MgCO_3 \xrightarrow{H_2SO_4} \underset{\text{Epsom Salt}}{MgSO_4 \cdot 7\,H_2O} \xrightarrow[800\,^{\circ}C]{Coke} MgO + SO_2 + CO_2$
5. $MgCO_3 \xrightarrow{HNO_3} Mg(NO_3)_2 \cdot 6\,H_2O$

11 Preparation and properties of Calcium compounds

1. $\boxed{CaO} \xrightarrow{P2O5} Ca_3(PO_4)_2$
2. $CaO \xrightarrow{SiO2} CaSiO_3$
3. $CaO \xrightarrow{H_2O} Ca(OH)_2 \xrightarrow{NH_4^+} NH_3$
4. $Ca(OH)_2 \longrightarrow CaCl_2 + Ca(ClO)_2$ or $Ca(OCl)Cl$
5. $CaO \xrightarrow{Coke\ +\ \Delta} CaC_2 \xrightarrow{N_2} \underset{\text{Nitrolim or Carbon Cynamide}}{CaCN_2}$
6. $CaC_2 \xrightarrow{H_2O} H_2C_2$

7. $\mathrm{CaOH} \xrightarrow{\mathrm{dil} \cdot \mathrm{H_2SO_4}} \underset{\text{Gypsum}}{\mathrm{CaSO_4 \cdot 2\,H_2O}} \xrightarrow{120^\circ\mathrm{C}} \underset{\text{Plaster of Paris}}{\mathrm{CaSO_4 \cdot \tfrac{1}{2}\,H_2O}} \xrightarrow{200^\circ\mathrm{C}} \mathrm{CaSO_4}$

$$\mathrm{CaSO_4 \cdot 2\,H_2O} \xrightarrow[\mathrm{BaCl_2}]{\mathrm{Barya\,ta\,H_2O}} \underset{\text{White}}{\mathrm{BaSO_4}\downarrow}$$

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