s-Block Elements

Section (A) : General facts about elements

The elements in which the last electron enters the outermost s-orbital are called s-block elements. As the s-orbital can accommodate only two electrons, two groups 1 and 2 belong to the s-block.

Flame Test

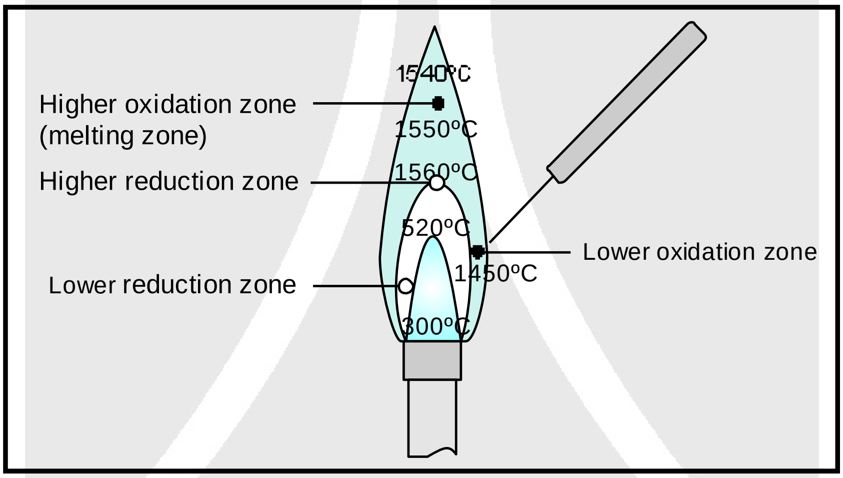
The alkali metals and alkaline earth metals and their salts impart characteristic colour to an oxidizing flame.

Reason: This is because the heat from the flame excites the outermost orbital electron to a higher energy level. When they drop back to the ground state, there is emission of radiation in the visible region.

The electrons in beryllium and magnesium are too strongly bound (due to small size) to get excited by flame. Hence, these elements do not impart any colour to the flame.

Metal	Li	Na	K	Rb	Cs
Colour	Crimson red	Yellow	Violet / Lilac	Red violet	Blue

Metal	Be	Mg	Ca	Sr	Ba
Colour	No colour	No colour	Brick red	Crimson red	Apple green



Section (B) Based on Periodic trends

Group – 1st(IA) Elements : (Alkali Metals)

Atomic and Physical properties of the Alkali metals

Property	**Lithium Li**	**Sodium Na**	**Potassium K**	**Rubidium Rb**	**Caesium Cs**	**Francium Fr**
Atomic number	3	11	19	37	55	87
Atomic mass (g mol^{-1})	6.94	22.99	39.10	85.47	132.91	(223)
Electronic configuration	[He] $2s^1$	[Ne] $3s^1$	[Ar] $4s^1$	[Kr] $5s^1$	[Xe] $6s^1$	[Rn] $7s^1$
Ionization enthalpy / kJ mol^{-1}	520	496	419	403	376	~375
Hydration enthalpy/kJ mol^{-1}	–506	–406	–330	–310	–276	–
Metallic radius / pm	152	186	227	248	265	–
Ionic radius M^+/ pm	76	102	138	152	167	(180)
m.p. / K	454	371	336	312	302	–
b.p / K	1615	1156	1032	961	944	–
Density / g cm^{-3}	0.53	0.97	0.86	1.53	1.90	–
Standard potentials $E^\ominus$/ V for (M^+/ M)	–3.04	–2.714	–2.925	–2.930	–2.927	–
Occurrence in lithosphere†	18*	2.27**	1.84**	78-12*	2-6*	~ 10^{-18}*

*ppm (part per million), ** Percentage by weight

Group IIA Elements (Alkaline Earth Metals)

Property	Beryllium Be	Magnesium Mg	Calcium Ca	Strontium Sr	Barium Ba	Radium Ra
Atomic number	4	12	20	38	56	88
Atomic mass (g mol^{-1})	9.01	24.31	40.08	87.62	137.33	226.03
Electron configuration	[He] $2s^2$	[Ne] $3s^2$	[Ar] $4s^2$	[Kr] $5s^2$	[Xe] $6s^2$	[Rn] $7s^2$
Ionization enthalpy (I) / kJ mol^{-1}	899	737	590	549	503	509
Ionization enthalpy (II) /kJ mol^{-1}	1757	1450	1145	1064	965	979
Hydration enthalpy (kJ/mol)	– 2494	– 1921	–1577	– 1443	– 1305	–
Metallic radius / pm	112	160	197	215	222	–
Ionic radius M^{2+}/ pm	31	72	100	118	135	148
m.p. / K	1560	924	1124	1062	1002	973
b.p / K	2745	1363	1767	1655	2078	(1973)
Density / g cm^{-3}	1.84	1.74	1.55	2.63	3.59	(5.5)
Standard potential $E^{\ominus}$ / V for (M^{2+}/ M)	–1.97	–2.36	–2.84	–2.89	– 2.92	–2.92
Occurrence in lithosphere	2*	2.76**	4.6**	384*	390*	10^{-6}*

Section (C) & (D) : Based on Chemical Bonding, Properties of elements

Properties of Alkali and Alkaline earth metals

S.No.	Atomic Properties	Alkali metals	Alkaline earth metals
1.	Outer Electronic configuration	ns^1	ns^2
2.	Oxidation number and valency	(i)These elements easily form univalent +ve ion by losing loosely solitary ns^1 electron due to low IP value.	The IP_1 of these metals are much lower than IP_2 and thus it appears that these metals should form univalent ion rather than divalent ions but in actual practice, all these give bivalent ion.
3.	Atomic and Ionic radii	Increase down the group, because value of n (principal quantum number) increases. Order = Li < Na < K < Rb < Cs.	The atomic and ionic radii of the alkali earth metal are smaller than corresponding alkali metals. Reason higher nuclear charge (Zeff) On moving down the group size increase, as value of n increases. Be < Mg < Ca < Sr < Ba
4.	Ionisation Energy	As size increases, I.E. decreases down the group (so Cs have lowest I.P.) Order = Li > Na > K > Rb > Cs	Down the group IE decreases due to increase in size. Be > Mg > Ca > Sr > Ba IE_1 of Alkali metal < IE_1 of Alkaline earth metal IE_2 of Alkali metal > IE_2 of Alkaline earth metal Reason IE_1 of Alkaline earth metal is large due to increased nuclear charge in Alkaline earth metal as compared to Alkali metal but IE_2 of Alkali metal is large because second electron in Alkali metal is to be removed from cation which has already acquired noble gas configuration
5.	Electropositive character or metallic character	Alkali metals are strongly electropositive and metallic. Down the group electropositive nature increase so metallic nature also increases. i.e. $M \rightarrow M^+ + e^-$ Metallic Nature: Electropositive character $\propto 1$ /I.P. Order = Li < Na < K < Rb < Cs.	Due to low IE they are strong electropositive but not as strong as Alkali metal because of comparatively high IE. The electropositive character increase down the group. Order = Be < Mg < Ca < Sr < Ba

6.	Hydration of ions	**(i)** Hydration represents for the dissolution of a substance in water to get absorb water molecule by weak valency forces Hydration of ions in the process when ions on dissolution in water get hydrated. **(ii)** Hydration energy $\propto$ charge density on ion Degree of hydration $\propto$ 1/Cation size $\propto$ charge $\propto$ 1/ionic mobility $\propto$ 1/conductivity Hydration energy = $Li^+ > Na^+ > K^+ > Rb^+ > Cs^+$ **(iii)** Li^+ being smallest in size has maximum degree of hydration and that is why lithium salts are mostly hydrated and moves very slowly under the influence of electric field. e.g : $LiCl.2H_2O$.	Hydration energy = $Be^{2+} > Mg^{2+} > Ca^{2+} > Sr^{2+} > Ba^{2+}$
7.	Photoelectric effect	The phenomenon of emission of electrons when electromagnetic rays strikes against them is called photoelectric effect; Alkali metal have low I.P. so show photoelectric effect. Cs and K are used in Photoelectric cells.	
8.	Electronegativity	**(i)**These metals are highly electopositive and there by possess low values of electro negativities. **(ii)**Electronegativity of alkali metals decreases down the group. Order = Li > Na > K > Rb > Cs	**(i)** Their electronegativities are also small but are higher than that of alkali metals **(ii)** Electronegativity decrease from Be to Ba

S.No.	Physical Property	Alkali metals	Alkaline earth metals
1.	Density	(i)All are light metals. (ii) Density increase down the group but K is lighter than Na. **Order** = Li < K < Na < Rb < Cs	**(i)** Heavier than alkali metals. **(ii)** Density decrease slightly up to Ca after which it increases. **(iii)** Density of Mg is greater than Ca.
2.	Hardness  The cutting of sodium metal	(i) All are silvery white metals. (ii) Light soft, malleable and ductile metals with metallic luster. (iii) Diamagnetic and colour less in form of ions. (iv) These metals are very soft and can be cut with a knife. Lithium is harder than any other alkali metal. The hardness depends upon cohensive energy. Cohensive energy $\propto$ Force of attraction between atoms.	Relatively soft but harder than Alkali metals.
3.	Melting points/ Boiling points	(i) Lattice energy decreases from Li to Cs and thus Melting points and Boiling points also decrease from Li to Cs. M.P. = Li > Na > K > Rb > Cs B.P. = Li > Na > K > Rb > Cs	They have low Melting points and Boiling points but are higher than corresponding value of group I. Reason They have two valence electrons which may participate in metallic bonding compared with only one electron in Alkali metal. Consequently group II elements are harder and have higher cohesive energy and so, have much higher Melting points / Boiling points than Alkali metal . M.P. = Be > Ca > Sr >Ba > Mg ,B.P. = Be > Ba > Ca > Sr > Mg
4.	Specific heat	It decreases from Li to Cs. Li > Na > K > Rb > Cs **(*need not to memorise)**	values are lesser than that of alkali metals, decreases down the group. **need not memorise.*

<table>
<tr><th>S.No.</th><th>Chemical Property</th><th>Alkali metals</th><th>Alkaline earth metals</th></tr>
<tr><td>1.</td><td>Action with O_2 and N_2</td><td>
(i) They generally form oxides and peroxides.
$M+O_2 \longrightarrow M_2O$ (Oxide) $\xrightarrow{O_2}$ M_2O_2 (Peroxide)
The alkali metals tarnish in dry air due to the formation of their oxides on their surface.
$4M + O_2 \longrightarrow 2M_2O$
They react vigorously in oxygen forming following oxides.
$4\,Li + O_2 \longrightarrow 2\,Li_2O$ (Monoxide)
$2\,Na + O_2 \longrightarrow Na_2O_2$ (Peroxide)
$M + O_2 \longrightarrow MO_2$ (Superoxide) where M = K, Rb, Cs
<table>
<tr><th colspan="4">Principal Combustion Product (Minor Product)</th></tr>
<tr><th>Metal</th><th>Oxide</th><th>Peroxide</th><th>Superoxide</th></tr>
<tr><td>Li</td><td>Li_2O</td><td>(Li_2O_2)</td><td></td></tr>
<tr><td>Na</td><td>(Na_2O)</td><td>Na_2O_2</td><td></td></tr>
<tr><td>K</td><td></td><td></td><td>KO_2(Orange/Yellow Crystalline)</td></tr>
<tr><td>Rb</td><td></td><td></td><td>RbO_2 (Orange/Yellow Crystalline)</td></tr>
<tr><td>Cs</td><td></td><td></td><td>CsO_2 (Orange/Yellow Crystalline)</td></tr>
</table>
The oxides and peroxides are colourless when pure.
(ii) All super oxide are paramagnetic and peroxides are diamagnetic in nature.
(iii) The increasing stability of the peroxide or superoxide as the size of the metal ion increases is due to the stabilisation of large anions by larger cations through lattice energy effect.
(iv) Since all the alkali metals are highly reactive towards air ; they are kept in kerosene oil. Reactivity increases from Li to Cs.
(v) Only Lithium reacts with N_2 (at room temperature) to form ionic lithium nitride Li_3N because Li being strongest reducing agent converts N_2 into N^{3-}.
$3Li + 1/2N_2 \longrightarrow Li_3N$
</td><td>
(i) Be and Mg are kinetically inert towards oxygen becasue of formation of a film of oxide on their surface. However powdered Be burn brilliantly.
$2Be + O_2\ (air) \xrightarrow{\Delta} 2BeO$(amphoteric) ;
$3Be + N_2\ (air) \xrightarrow{\Delta} Be_3N_2$
(ii) Mg is more electropositive and burns with dazzling brilliance in air give MgO and Mg_3N_2.
$Mg + O_2(air) \xrightarrow{\Delta} MgO$;
$Mg + N_2(air) \xrightarrow{\Delta} Mg_3N_2$
Peroxides are coloured due to lattice defect.
(Similar property with Li because both shows diagonal relation.)
(iii) Ba gives BaO_2 not BaO.
(iv) Calcium, strontium and barium are readily attacked by air to form the oxide and nitride. They also react water with increasing vigour even in cold to form hydroxides.
(v) BeO, MgO are used as refractory, because they have high M.P.
(vi) Other metals (Ba or Sr form peroxide)
$M + O_2 \xrightarrow{\Delta} MO_2$
</td></tr>
<tr><td>2.</td><td>Action with water</td><td>
(i) Alkali metals decompose water to form the hydroxides having the formula MOH and dihydrogen.
$2M + 2H_2O \longrightarrow 2MOH(aq.) + H_2(g)$ (M = An alkali metal).
(ii) Li decompose water slowly, sodium reacts with water quickly K, Rb and Cs react with water vigorously.
(iii) It may be noted that although lithium has most negative $E^{\ominus}$ value (In below table), its reaction with water is less vigorous than that of sodium which has the least negative $E^{\ominus}$ value among the alkali metals. This behaviour of lithium is attributed to its small size and very high hydration energy. It's explanation lies in Kinetics, released energy in case of K, Rb, Cs is sufficient to melt or even vapourise and so more surface area is exposed to the water and kinetically reaction is faster than lithium. Other metals of the group react explosively with water.
<table>
<tr><th rowspan="2">Property</th><th colspan="6">Alkali metals</th></tr>
<tr><th>Li</th><th>Na</th><th>K</th><th>Rb</th><th>Cs</th><th>Fr</th></tr>
<tr><td>Standard potentials $E^{\ominus}$/V for (M^+/M)</td><td>– 3.04</td><td>– 2.714</td><td>– 2.925</td><td>– 2.930</td><td>– 2.927</td><td>–</td></tr>
</table>
(iv) They also react with proton donors such as alcohol, gaseous ammonia and terminal alkynes evolution of hydrogen.
$2M + 2C_2H_5OH \longrightarrow 2C_2H_5OM + H_2$
Ethyl alcohol   Metal ethoxide
</td><td>
(i) Ca, Sr, Ba and Ra decompose cold water readily with evolution of hydrogen.
$M + 2H_2O \longrightarrow M(OH)_2 + H_2$
(ii) Magnesium decomposes boiling water but beryllium is not attacked by water even at high temperatures as its oxidation potential is lower than the other members
</td></tr>
<tr><td>3.</td><td>Hydrides</td><td>
(i)They react with H_2 forming metal hydride with formula MH which are of ionic nature. Stability of hydride decreases down the group. Since the electropositive character decreases from Cs to Li.
$2M + H_2 \longrightarrow 2M^{\oplus}H^{\ominus}$
</td><td>
(i) Except Be, all alkaline earth metals form hydrides (MH_2) on heating directly with H_2.
(ii)The stability of hydrides decreases from Be to Ra.
(iii) BeH_2 is prepared by the action of $LiAlH_4$ on $BeCl_2$.
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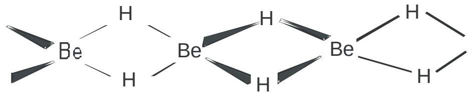
<td>(iii) The metal hydrides react with water to give MOH and H_2. (act as reducing agent)
$MH + H_2O \longrightarrow MOH + H_2$</td>
<td>$BeCl_2 + LiAlH_4 \longrightarrow 2BeH_2 + LiCl + AlCl_3$
BeH_2 & MgH_2 is covalent and polymeric but other are ionic.

(iv) The ionic hydrides of Ca, Sr, Ba liberate H_2 at anode and metal at cathode.</td>
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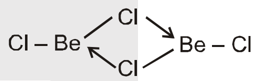
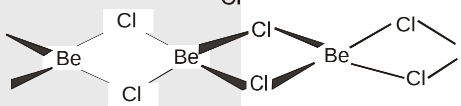
<td>4.</td>
<td>Halides</td>
<td>(i)The alkali metals react vigorously with halogens to form ionic halides M^+X^-.
$2M + X_2 \longrightarrow 2\,M^+X^-$
(ii) Alkali metals halides (Cl_2, Br_2, I_2) formation is increases form Li to Cs due to increase in electropositive character.
Order of reactivity towards F_2
Li > Na > K > Rb > Cs
(iii) LiX have more covalent character (It is because of the high polarisation capability of Lithium ion (fajan's rules)).
(iv)Halides having ionic nature have high melting point and are good conductor of current in fused state. These are readily soluble in water.
(v) Halides of potassium, rubidium and ceasium have property of combining with extra halogen atoms forming polyhalides.
$KI + I_2 \longrightarrow KI_3$</td>
<td>(i)The alkaline earth metals directly combine with halogens on heating to give metal halides MX_2 (X=F,Cl,Br,I)
(ii) Thermal decomposition of $(NH_4)_2BeF_4$ is the best route for the preparation of BeF_2, and $BeCl_2$ is conveniently made from the oxide.
$BeO + C + Cl \overset{600\text{-}800\,K}{\rightleftharpoons} BeCl_2 + CO$
Anhydrous beryllium halide can not be obtained from materials made in aqueous solution because the hydrated ions $[Be(H_2O)_4]^{2+}$ is formed. i.e. $[Be(H_2O)_4]Cl_2$
On dehydration, hydrolysis takes place.
$[Be(H_2O)_4]Cl_2 \xrightarrow{heat} Be(OH)_2 + 2HCl$
(iii) Except for beryllium halides, all other halides of alkaline earth metals are ionic in nature. Beryllium halides are essentially covalent and soluble in organic solvents. Beryllium chloride has a chain structure in the solid state as shown below :
Cl–Be–Cl


In the vapour phase $BeCl_2$ tends to form a chloro-bridged dimer which dissociates into the linear monomer at high temperatures of the order of 1200 K.
(iv)The ionic character of halides increases from Be to Ra.
(v)Beryllium halides have covalent character due to small size and high effective nuclear charge and thus do not conduct electricity in molten state.
(vi) The fluorides are relatively less soluble than the chlorides owing to their high lattice energies.
(vii)The decreases in solubility of halides down the group is due to decrease in hydration energy because of increasing size of metal cation .
(viii) The tendency to form halide hydrates gradually decreases (for example, $MgCl_2{\cdot}6H_2O$, $CaCl_2{\cdot}6H_2O$, $SrCl_2{\cdot}6H_2O$ and $BaCl_2{\cdot}2H_2O$) down the group. The dehydration of hydrated chlorides, bromides and iodides of Ca, Sr and Ba can be achieved on heating; however, the corresponding hydrated halides of Be and Mg on heating suffer hydrolysis.
(ix) CaCl2 has strong affinity with water and is used as dehydrating agent.</td>
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<td>5.</td>
<td>Reducing nature
(*need not to memorise)</td>
<td><table>
<tr><td rowspan="2">Property</td><td colspan="6">Alkali metals</td></tr>
<tr><td>Li</td><td>Na</td><td>K</td><td>Rb</td><td>Cs</td><td>Fr</td></tr>
<tr><td>Standard potentials $E^{\ominus}$/V for (M^+/M)</td><td>– 3.04</td><td>– 2.714</td><td>– 2.925</td><td>– 2.930</td><td>– 2.927</td><td>–</td></tr>
</table>(i) Reducing agent is electron donor. The alkali metals are strong reducing agents, lithium being the most and sodium the least powerful (above table). The standard electrode potential ($E^{\ominus}$) which measures the reducing power represents the overall change :</td>
<td>The alkaline earth metals are strong reducing agents. This is indicated by large negative values of their reduction potentials (below table). However their reducing power is less than those of their corresponding alkali metals. Beryllium has less negative value compared to other alkaline earth metals.
However, its reducing nature is due to large hydration energy associated with the small size of Be^{2+} ion and relatively large value of the atomization enthalpy of the metal.</td>
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<td>$M(s) \longrightarrow M(g)$ Sublimation enthalpy
$M(g) \longrightarrow M^+(g) + e^-$ Ionization enthalpy
$M^+(g) + H_2O \longrightarrow M^+ (aq)$ Hydration enthalpy
(ii) Lithium is expected to be least reducing agent due to it's very high I.E. However, lithium has the highest hydration enthalpy which accounts for its high negative $E^{\ominus}$ value and its high reducing power.
Reducing Nature in gas phase
$= Li < Na < K < Rb < Cs$.
Reducing Nature in aqueous condition
$= Li > Cs > Rb > K > Na$.</td>
<td>
<table>
<tr><td rowspan="2">Property</td><td colspan="6">Alkaline earth metals</td></tr>
<tr><td>Be</td><td>Mg</td><td>Ca</td><td>Sr</td><td>Ba</td><td>Ra</td></tr>
<tr><td>Standard potentials $E^{\ominus}$/V for (M^+/M)</td><td>– 1.97</td><td>– 2.36</td><td>– 2.84</td><td>– 2.89</td><td>– 2.92</td><td>– 2.92</td></tr>
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<tr>
<td>6.</td>
<td>Basic nature of hydroxide</td>
<td>(i) These oxides are easily hydrolysed by water to form the hydroxides.
Thus M_2O (oxide) + $H_2O \longrightarrow M^{\oplus}OH^{\ominus}$
M_2O_2 (peroxide) + $H_2O \longrightarrow 2\,M^{\oplus}OH^{\ominus} + H_2O_2$
MO_2 (superoxide) + $H_2O \longrightarrow 2\,M^{\oplus}OH^{\ominus} + H_2O_2 + O_2$
(ii) The Hydroxide which are obtained by the reaction of the oxide. With water all are white crystalline solids. The alkali metal hydroxides are the strongest of all bases and dissolve freely in water with evolution of much heat an account of intense hydration.
Basic nature/Solubility in water/Thermal stability
$= LiOH < NaOH < KOH < RbOH < CsOH$</td>
<td>Basic/thermal stability

$= Be(OH)_2 < Mg(OH)_2 < Ca(OH)_2 < Sr(OH)_2 < Ba(OH)_2$</td>
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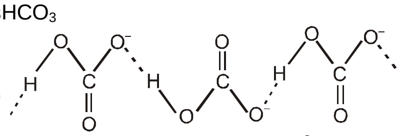
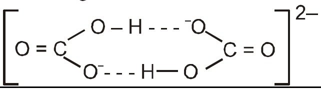
<td>7.</td>
<td>Carbonates and bicarbonates</td>
<td>(i) The carbonates (M_2CO_3) and bicarbonates ($MHCO_3$) are highly stable to heat, where M as alkali metals.
(ii) Group 1 metals are so strongly basic, they (except lithium) also form solid bicarbonates. No other metals form solid bicarbonates. Lithium carbonate is not so stable to heat. Its hydrogencarbonate does not exist as a solid. Although NH_4HCO_3 also exists as a solid.
(iii) The stability of these salts increases with the increasing electropositive character from Li to Cs. It is therefore Li_2CO_3 decompose on heating.
Thermal stability/Solubility in water.
$Li_2CO_3 < Na_2CO_3 < K_2CO_3 < Rb_2CO_3 < Cs_2CO_3$
$LiHCO_3$ does not exist in solid form due to high polarizing power of Li^+ and uncomparable size of Li^+ cation and HCO_3^- anion.
$Li_2CO_3 \xrightarrow{\Delta} Li_2O + CO_2$
(iv) Bicarbonates are decomposed at relatively low temperature.
$2MHCO_3 \xrightarrow{300^{\circ}C} M_2CO_3 + H_2O + CO_2$
(v) Hydrolysis of carbonate
$Na_2CO_3 + 2H_2O \longrightarrow 2NaOH + H_2CO_3$
$Li_2CO_3 + 2H_2O \longrightarrow$ sparingly soluble
(vi) The crystal structures of $NaHCO_3$ and $KHCO_3$ both show hydrogen bonding, but are different.
(a) In $NaHCO_3$, the HCO_3^- ions are linked into an infinite chain.
(b) in $KHCO_3$, $RbHCO_3$, $CsHCO_3$, HCO_3^- forms a dimeric anion.
Solubility in water $NaHCO_3 < KHCO_3 < RbHCO_3 < CsHCO_3$
(a) 
(b) </td>
<td>(i) All these metal carbonates MCO_3 are insoluble in neutral medium but soluble in acids and decompose on red heating.
(ii) The stability of carbonates increases with increase in electropositive character of metal.
$BeCO_3 < MgCO_3 < CaCO_3 < SrCO_3 < BaCO_3$
(iii) Bicarbonates of alkaline earth metals do not exist in solid state but are known in solution only on heating their solution bicarbonates decomposed to liberate CO_2 .
$M(HCO_3)_2 \xrightarrow{\Delta} MCO_3 + CO_2 + H_2O$
(Solution)
(iv)Solubility of carbonates decrease on moving down the group.
$BeCO_3 > MgCO_3 > CaCO_3 > SrCO_3 > BaCO_3$</td>
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<tr>
<td>8.</td>
<td>Complex ion formation</td>
<td>(i) A metal shows complex formation only when it has following characteristics.
(a) Small size, (b) High nuclear charge, (c) Presence of empty orbitals in order to accept electron pair from ligand (electron pair donor species).
(ii) Due to small size only Lithium in alkali metals, forms a few complex ions. Rest all alkali metals do not possess the tendency to form complex ion.</td>
<td>Be^{2+} on account of smaller size forms many complexes such as $[Be F_3]^-$, $[BeF_4]^{2-}$
Chlorophyll contains Mg^{2+} [Photosynthetic pigment in plants] (C.No.= 4)
$[Be(H_2O)_4]^{2+} + H_2O \longrightarrow [Be(H_2O)_3OH]^+ + H_3O^+$</td>
</tr>
</table>

9.	Reaction with acids	Reacts vigorously with acids $2M + H_2SO_4 \longrightarrow M_2SO_4 + H_2$	The alkaline earth metals readily react with acids liberated dihydrogen. $M + 2HCl \longrightarrow MCl_2 + H_2$
10.	Formation of amalgams	(i) Alkali metals get dissolved in mercury to form amalgams with evolution of heat and the amalgamation is highly exothermic. (ii) Alkali metals form alloys themselves as well as with other metals.	Alkaline earth metals get dissolved in mercury to form amalgams with evolution of heat and the amalgamation is highly exothermic.
11.	Sulphates	(i) All these form sulphates of type M_2SO_4. (ii) Except Li_2SO_4 rest all are soluble in water. Thermal stability /solubility in water $Li_2SO_4 < Na_2SO_4 < K_2SO_4 < Rb_2SO_4 < Cs_2SO_4$ (iii)These sulphates on fusing with carbon form sulphides. $M_2SO_4 + 4C \longrightarrow M_2S + 4CO$	(i) MSO_4 type sulphates are formed (ii)The solubility of sulphates decreases on moving down the group. The sulphates of the alkaline earth metals are all white solids and stable to heat. $BeSO_4$, and $MgSO_4$ are readily soluble in water; the solubility decreases from $CaSO_4$ to $BaSO_4$. The greater hydration enthalpies of Be^{2+} and Mg^{2+} ions overcome the lattice enthalpy factor and therefore their sulphates are soluble in water. Thermal stability $BeSO_4 < MgSO_4 < CaSO_4 < SrSO_4 < BaSO_4$ Solubility in water $BeSO_4 > MgSO_4 > CaSO_4 > SrSO_4 > BaSO_4$
12.	Sulphides	All metals react with S forming sulphides such as Na_2S and Na_2Sn (n = 2, 3, 4, 5 or 6). The polysulphide ions are made from zig-zag chains of sulphur atoms.	(iii) $MSO_4 + 2C \longrightarrow MS + 2CO_2$ $M^{2+} + S^{2-} \longrightarrow MS$
13.	Nitrates	(i) Nitrates of both are soluble in water and decompose on heating. (ii) $LiNO_3$ decomposes to give NO_2 and O_2 and rest all give nitrites and oxygen. $2MNO_3 \longrightarrow 2MNO_2 + O_2$ (except Li) $4LiNO_3 \longrightarrow 2Li_2O + 4NO_2 + O_2$ $2NaNO_3 \xrightarrow[500°C]{\Delta} 2NaNO_2 + O_2$ $2NaNO_3 \xrightarrow[800°C]{\Delta} Na_2O + N_2 + O_2$ $2NaNO_3 \xrightarrow{Na} Na_2O + N_2 + O_2$	On heating they decompose into their corresponding oxides with evolution of a mixture of nitrogen dioxide and oxygen. $M(NO_3)_2 \longrightarrow MO + 2NO_2 + ½O_2$ (M = Be, Mg , Cr, Sr, Ba)
14.	Nitride	$Li_3N + 3H_2O \longrightarrow 3LiOH + NH_3\uparrow$	$Be_3N_2 + 6H_2O \longrightarrow 3Be(OH)_2 + 2NH_3\uparrow$ $Mg_3N_2 + 6H_2O \longrightarrow 3Mg(OH)_2 + 2NH_3\uparrow$
15.	Carbide	When Li is heated with carbon, an ionic carbide Li_2C_2 is formed. $2Li + 2C \longrightarrow Li_2C_2$ Other metals do not react with carbon directly but form carbides when heated with ethyne, or when ethyne is passed through a solution of metal in liquid ammonia. $Na + C_2H_2 \longrightarrow NaH + C_2 \longrightarrow Na_2C_2$ $[C{\equiv}C{-}H]^-$ $[C{\equiv}C]^{2-}$ $Na_2C_2 + 2H_2O \longrightarrow NaOH + C_2H_2$	The binary compounds of carbon with other elements (less electronegative or of similar electronegativity) are called carbides. They are classified into following 3 categories : (i) Ionic (ii) Covalent (iii) Interstitial (or metallic) **(i) Ionic carbides (or salt like carbides) :** Generally formed by the most electropositive elements such as alkali and alkaline earth metals and aluminium (Boron is exception). Based on the product obtained on hydrolysis, they are further sub-classified into three types. **(a) Methanides :** These give CH_4 on reaction with H_2O. $Al_4C_3 + 12H_2O \longrightarrow 4Al(OH)_3 + 3CH_4$; $Be_2C + 4H_2O \longrightarrow 2Be(OH)_2 + CH_4$ These carbides contain C^{4-} ions in their constitution. **(b) Acetylides :** These give C_2H_2 on reaction with H_2O. $CaC_2 + 2H_2O \longrightarrow Ca(OH)_2 + C_2H_2$ $Al_2(C_2)_3 + 6H_2O \longrightarrow 2Al(OH)_3 + 3C_2H_2$ $SrC_2 + 2H_2O \longrightarrow Sr(OH)_2 + C_2H_2$ Such compounds contain C_2^{2-} ions. **(c) Allylides :** These give 1-propyne on reaction with H_2O. $Mg_2C_3 + 4H_2O \longrightarrow 2Mg(OH)_2 + CH_3{-}C{\equiv}CH$ Such compounds contain C_3^{4-} $[:\ddot{C}{-}C{\equiv}C:]^{4-}$ ions. **Covalent carbides :** Molecules like SiC and B_4C are also examples of covalent carbides.

			Interstitial or metallic carbides Such carbides are formed by transition metals and some of the lanthanides and actinides. Interstitial carbides retain many of the properties of metals. They conduct electricity by metallic conduction and have properties of metals (a lusture like a metal). In these compounds carbon atoms occupy octahedral holes in the closed packed metal lattice. These are generally very hard and have very high melting point (e.g. WC). Carbides of Cr, Mn, Fe, Co and Ni are hydrolysed by water or dilute acids.

Lattice Energy: Energy change when one mole of crystalline lattice is formed from gaseous ions

eg. $2Al^{3+} + 3O^{2-} \longrightarrow Al_2O_3 + L.E.$

Hydration Energy: It is the energy change when gaseous ions form aqueous ions.

eg. $Na^+ + aq. \longrightarrow Na^+ + H.E.\ of\ Na^+$

$SO_4^{2-} + aq. \longrightarrow SO_4^{2-} + H.E.\ of\ SO_4^{2-}$

Solutions in liquid NH_3

Alkali metals dissolve in liquid ammonia (high conc. 3 M) and give blue solution which is conducting, reducing and paramagnetic in nature.

Reason

On dissolving Metal in NH_3

$M(s) + NH_3(\ell) \longrightarrow M^+_{(NH_3)} + e^-_{(NH_3)}$

$M^+ + x\,(NH_3) \longrightarrow [M(NH_3)_x]^+$ $\longrightarrow$ Ammoniated cation

$e^- + y\,(NH_3) \longrightarrow [e(NH_3)_y]^-$ $\longrightarrow$ Ammoniated electron

The blue colour is due to $\longrightarrow$ Ammoniated electron

The paramagnetic nature is due to $\longrightarrow$ Ammoniated electron

The conducting nature is due to $\longrightarrow$ Ammoniated M^+ + Ammoniated electron

On standing the colour fades due to formation of amide after liberating hydrogen.

$$M^+ + e^- + NH_3 \longrightarrow MNH_2(amide) + H_2(g)$$

In the absence of impurities like. Fe, Pt, Zn etc, the solutions are stable.

In concentrated solution, the blue colour changes to bronze colour and diamagnetic due to the formation of metal clusters and ammoniated electrons also associate to form electron pairs

$$2e^-\,(NH_3)_y \longrightarrow [\,e^-(NH_3)_y]_2$$

Solutions are of much lower density than the pure solvent, i.e., they occupy for greater volume than that expected from the sum of the volumes of metal and solvent

Peroxide and superoxides of Na & K are widely used as oxidising agent and air purifiers in space capsules, submarines and breathing mask.

Alkaline metal in liq. NH_3

Like alkali metals, the alkaline earth metals dissolve in liquid ammonia to give deep blue black solutions forming ammoniated ions

$M + (x + y)NH_3 \longrightarrow [M(NH_3)_x]^{2+} + 2[e(NH_3)_y]^-$

From these solutions, the hexa-ammoniates $[M(NH_3)_6]^{2+}$ can be recovered.

Uses of alkali metal

(1) Lithium metal is used to make useful alloys,
- with lead to make 'white metal' bearings for motor engines.
- with aluminium to make aircraft parts.
- with magnesium to make armour plates.

(2) It is used in thermonuclear reactions.

(3) Lithium is also used to make electrochemical cells.

(4) Sodium is used to make a Na/Pb alloy needed to make $PbEt_4$ and $PbMe_4$. These organolead compounds were earlier used as anti-knock additives to petrol, but nowadays vehicles use lead-free petrol.

(5) Liquid sodium metal is used as a coolant in fast breeder nuclear reactors.

(6) Potassium chloride is used as a fertilizer.

(7) Potassium hydroxide is used in the manufacture of soft soap. It is also used as an excellent absorbent of carbon dioxide.
(8) Caesium is used in devising photoelectric cells.

Uses of alkaline metal

(1) Beryllium is used in the manufacture of alloys.
(2) Copper-beryllium alloys are used in the preparation of high strength springs.
(3) Metallic beryllium is used for making windows of X-ray tubes.
(4) Magnesium forms alloys with aluminium, zinc, manganese and tin. Magnesium-aluminium alloys being light in mass are used in air-craft construction.
(5) Magnesium (powder and ribbon) is used in flash powders and bulbs, incendiary bombs and signals.
(6) A suspension of magnesium hydroxide in water (called *milk of magnesia*) is used as antacid in medicine.
(7) Magnesium carbonate is an ingredient of toothpaste.
(8) Calcium is used in the extraction of metals from oxides which are difficult to reduce with carbon.
(9) Calcium and barium metals, owing to their reactivity with oxygen and nitrogen at elevated temperatures, have often been used to remove air from vacuum tubes.
(10) Radium salts are used in radiotherapy, for example, in the treatment of cancer.

Biological Importance Of Sodium And Potassium:

- Sodium ions are found primarily on the outside of cells, being located in blood plasma and in the interstitial fluid which surrounds the cells. These ions participate in the transmission of nerve signals, in regulating the flow of water across cell membranes and in the tranasport of sugars and amino acids into cells. Sodium and potassium, although so similar chemically, differ quantitatively in their ability to penetrate cell membranes, in their transport mechanisms and in their efficiency to activate enzymes. Thus, potassium ions are the most aundant cations within cell fluids, where they activate many enzymes, participate in the oxidation of glucose to produce ATP and, with sodium, are responsible for the transmission of nerve signals

A typical 70 kg man contains about 90 g of Na and 170 g of K compared with only 5 g of iron and 0.06 g of copper.

Biological Importance of Magnesium and Calcium :

- Monovalent sodium and potassium ions and divalent magnesium and calcium ions are found in large proportions in **biological fluids**. These ions perform important **biological functions** such as maintenance of ion balance and nerve impulse conduction.
- All enzymes that utilise ATP in phosphate transfer require magnesium as the cofactor. The main pigment for the absorption of light in plants is chlorophyll which contains magnesium. About 99 % of body calcium is present in bones and teeth. It also plays important roles in neuromuscular function, interneuronal transmission, cell membrane integrity and blood coagulation.
- The calcium concentration in plasma is regulated at about 100 mgL^{-1}. It is maintained by two hormones : calcitonin and parathyroid hormone. Do you know that bone is not an inert and unchanging substance but is continuously being solubilised and redeposited to the extent of 400 mg per day in man? All this calcium passes through the plasma.

An adult body contains about 25 g of Mg and 1200 g of Ca compared with only 5 g of iron and 0.06 g of copper. The daily requirement in the human body has been estimated to be 200–300 mg.

ANOMALOUS PROPERTIES OF LITHIUM

The anomalous behavior of lithium is due to the :
(i) Exceptionally small size of its atom and ion,
(ii) High polarising power (i.e., charge/ radius ratio).
As a result, there is increased covalent character of lithium compound which is responsible for their solubility in organic solvent. Further, lithium shows diagonal relationship to magnesium.

S.No.	Property	Li
1.	Hardness	Li is much harder.
2.	M.P and B.P	Higher M.P and B.P
3.	Reactivity	Less reactive
4.	Reducing agent	Strong
5.	Combustion in air	Li form monoxide (Li_2O) and nitride (Li_3N) ; not for other.

6.	Hydration of ion	Favored for Li$^{\oplus}$; not for other. Li$^{\oplus}$ has maximum degree of hydration for this reason. Lithium salts are mostly hydrated. E.g $LiCl.2H_2O$.
7.	Hydrogen Carbonate	Li is not obtained in the solid form while all other elements form solid hydrogen carbonates.
8.	Ethynide	Favored for Li$^{\oplus}$; not for other.
9.	Lithium nitrate	$4LiNO_3 \xrightarrow{\Delta} 2Li_2O + 4NO_2 + O_2$ (Lithium Oxide) Where as other alkali metal nitrates decompose to give the corresponding nitrite. $2NaNO_3 \xrightarrow{\Delta} 2NaNO_2 + O_2$ (Sodium nitrite)
10.	LiF and Li_2O	These are much less soluble in water. Solubility in water is less than the corresponding compounds of other alkali metal.
11.	Carbide	Li reacts directly with carbon to form anionic carbide.
12.	Hydroxide	Lithium hydroxide is less basic Li_2CO_3, $LiNO_3$ and LiOH all form the oxides on gentle heating.
13.	Carbonate	Less stable.
14.	Nitrite	Less stable.
15.	Bicarbonate	Lithium forms a bicarbonates in solution it does not form a solid bicarbonate. Where as the other all forms stable solid bicarbonates.
16.	Complex ion formation	Lithium has a great tendency to form. Complexes not for other. Due to small size of Lithium.
17.	Reaction with NH_3	Li when heated in NH_3 imide (Li_2NH) while other alkali metals form amides (MNH_2)

Points of Similarities between Lithium and Magnesium

The similarity between lithium and magnesium is particularly striking and arises because of their similar size: atomic radii, Li = 152 pm, Mg = 160 pm; ionic radii : Li^+ = 76 pm, Mg^{2+} = 72 pm. The main points of similarity are :

S.No.	Properties	Li and Mg
1.	Hardness	Li and Mg are much harder.
2.	Density	These are lighter than other elements in the respective group.
3.	Reaction with water	Both react slowly with water.
4.	Solubility of hydroxide and oxide	Less soluble and their hydroxides decompose in acid on heating.
5.	Reaction with N_2	By direct combination with nitrogen both form a nitride Li_3N and Mg_3N_2.
6.	Oxides	The oxides Li_2O and MgO donot combine with excess oxygen to give any superoxide.
7.	Carbonates	Carbonates of both decompose easily on heating to form the oxides and CO_2. Solid hydrogen carbonates are not formed by Li and Mg.
8.	Solubility of halides in ethanol	Both LiCl and $MgCl_2$ are soluble.
9.	Hydration of ion	Both LiCl and $MgCl_2$ are deliquescent and crystallise from aqueous solution as hydrates, $LiCl.H_2O$ and $MgCl_2.6H_2O$.

Anamolous Behaviour of Beryllium

The properties of beryllium the first member of the alkaline earth metal, differ from the rest of the member. Its is mainly because of

(i) Its small size and high polarizing power.

(ii) Relatively high electro negativity and ionization energy as compared to other members.

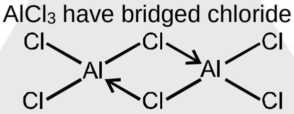
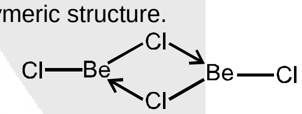
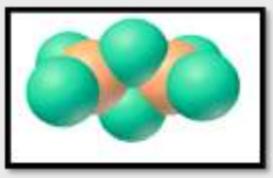
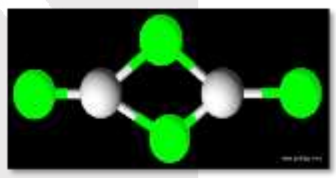
(iii) Absence of vacant d–orbitals in its valence shell.

Some important points of difference between beryllium and other members (especially magnesium) are given below.

S.No.	Properties	
1.	Hardness	Be is harder than other members of its group
2.	Density	Be is lighter than Mg
3.	M.P. and B.P.	Higher then other members of its group.
4.	Reaction with water	Be does not react with water while Mg reacts with boiling water.
5.	Nature of oxides	BeO is amphoteric while MgO is weakly basic.
6.	Nature of compounds	Be forms covalent compounds whereas other members form ionic compounds.
7.	Carbide	Beryllium carbide reacts with water to give methane whereas carbides of other alkaline earth metals gives acetylene gas. $Be_2C + 4H_2O \rightarrow 2Be(OH)_2 + CH_4$ $MgC_2 + 2H_2O \rightarrow Mg(OH)_2 + C_2H_2$ $CaC_2 + 2H_2O \rightarrow Ca(OH)_2 + C_2H_2$
8.	Hydride	The beryllium hydride is electron deficient and polymeric, with muti center bonding like aluminium hydride.
9.	Co-ordination number	Beryllium does not exhibit coordination number more than four as it has four orbitals in the valence shell. The other members of this group has coordination number 6.
10.	Reaction with Alkali	Be dissolves in alkalies with evolution of hydrogen $Be + 2NaOH + 2H_2O \rightarrow Na_2BeO_2.2H_2O + H_2$ (sodium beryllate Other alkaline earth metals don't react with alkalies.

Resemblance of Beryllium with Aluminium (Diagonal relationship)

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

S.No.	Properties	Be and Al
1.	Nature of compounds	Unlike groups-2 elements but like aluminium, beryllium forms covalent compounds.
2.	Nature of hydroxide	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.
3.	Nature of oxide	The oxides of both Be and Al i.e. BeO and Al_2O_3 are high melting insoluble solids.
4.	Polymeric structure	$BeCl_2$ and $AlCl_3$ have bridged chloride polymeric structure.  
5.	Salts	The salts of beryllium as well as aluminium are extensively hydrolysed.
6.	Carbides	Carbides of both the metal reacts with water liberating methane gas. $Be_2C + 4H_2O \rightarrow 2Be(OH)_2 + CH_4$ $Al_4C_3 + 12H_2O \rightarrow 4Al(OH)_3 + 3CH_4$
7.	Oxides and hydroxides	The oxides and hydroxides of both Be and Al are amphoteric and dissolve in sodium hydroxide as well as in hydrochloric acid. $BeO + 2HCl \rightarrow BeCl_2 + H_2O$ $BeO + 2NaOH \rightarrow Na_2BeO_2 + H_2O$ $Al_2O_3 + 6HCl \rightarrow 2AlCl_3 + H_2O$ $Al_2O_3 + 2NaOH \rightarrow 2NaAlO_2 + H_2O$
8.	Reaction with acids	Like Al, Be is not readily attacked by acids because of the presence of an oxide film.

Section (E) : Oxides, Peroxides, Super Oxides, Hydroxides

GROUP -I & II OXIDES

1. Sodium Oxide (Na_2O)

Preparation:

Name of compound	Name and Brief about the process	Related chemical reaction
Sodium Oxide (Na_2O)	(1) By burning sodium at 180°C in a limited supply of air or oxygen and distilling off the excess of sodium in vacuum.	$2Na + \frac{1}{2}O_2 \xrightarrow{180^\circ} Na_2O$
	(2) By heating sodium peroxide, nitrate or nitrite with sodium.	$Na_2O_2 + 2Na \longrightarrow 2Na_2O$ $2NaNO_3 + 10Na \longrightarrow 6Na_2O + N_2$ $2NaNO_2 + 6Na \longrightarrow 4Na_2O + N_2$
	(3) Sodium oxide is formed when the mixture of sodium azide and sodium nitrite is heated.	$3NaN_3 + NaNO_2 \longrightarrow 2Na_2O + 5N_2$

Chemical Properties:

(1) It is white amorphous substance.

(2) It dissolve violently in water, yielding caustic soda (NaOH) and evolving a large amount of heat.

$$Na_2O + H_2O \longrightarrow 2NaOH$$

Uses : It is used as dehydrating and polymerising agent in organic chemistry.

2. Sodium Peroxide (Na_2O_2)

Preparation

Name of compound	Name and Brief about the process	Related chemical reaction
Sodium Peroxides (Na_2O_2)	(1) By heating the metal in excess of air or oxygen at 300°, which is free from moisture and CO_2.	$2Na + O_2 \text{ (excess)} \xrightarrow{300^\circ C} Na_2O_2$
	(2) **Industrial method :** It is a two stage reaction in the presence of excess air.	$2Na + O_2 \longrightarrow Na_2O$ $Na_2O + O_2 \longrightarrow Na_2O_2$

Properties:

(1) It is a pale yellow solid (when impure), becoming white in air from the formation of a film of NaOH and Na_2CO_3.

(2) In cold water (~0°C) produces H_2O_2 but at room temperature produces O_2. In ice-cold mineral acids also produces H_2O_2.

$$Na_2O_2 + 2H_2O \xrightarrow{\sim 0^\circ C} 2NaOH + H_2O_2$$
$$2Na_2O_2 + 2H_2O \xrightarrow{25^\circ C} 4NaOH + O_2$$
$$Na_2O_2 + H_2SO_4 \xrightarrow{\sim 0^\circ C} Na_2SO_4 + H_2O_2$$
$$2Na_2O_2 + H_2SO_4 \xrightarrow{25^\circ C} 2Na_2SO_4 + 2H_2O + O_2$$

(3) It reacts with CO_2, giving sodium carbonate and oxygen and hence its use for purifying air in a confined space e.g. submarine, ill-ventilated room.

$$2Na_2O_2 + 2CO_2 \longrightarrow 2Na_2CO_3 + O_2$$
$$Na_2O_2 + CO \longrightarrow Na_2CO_3$$

(4) It is an oxidising agent and oxidises charcoal, CO, NH_3, SO_2.

$$3Na_2O_2 + 2C \longrightarrow 2Na_2CO_3 + 2Na \text{ [deposition of metallic Na]}$$
$$CO + Na_2O_2 \longrightarrow Na_2CO_3$$
$$SO_2 + Na_2O_2 \longrightarrow Na_2SO_4$$
$$2NH_3 + 3Na_2O_2 \longrightarrow 6NaOH + N_2$$

(5) Sulphides are oxidised to corresponding sulphates

$$Na_2O_2 \longrightarrow Na_2O + [O] \quad ; \qquad Na_2S + 4[O] \longrightarrow Na_2SO_4$$

(6) $Na_2O_2 \longrightarrow Na_2O + [O]$; $2Al + 3[O] \longrightarrow Al_2O_3$; $Al_2O_3 + Na_2O \longrightarrow 2NaAlO_2$.

Uses :

(1) For preparing H_2O_2, O_2.

(2) Oxygenating the air in submarines.

(3) Oxidising agent in the laboratory.

Oxides of Potassium	K_2O	K_2O_2	K_2O_3*	KO_2	KO_3
Colours	White	White	Red	Bright Yellow	Orange Red Solid

3. Potassium sesquioxide (need not memorize).
Preparation:

Name of compound	Name and Brief about the process	Related chemical reaction
K_2O (Potassium oxide)	By heating potassium nitrate with potassium.	$2KNO_3 + 10K \xrightarrow{heating} 6K_2O + N_2$ $\underset{(White)}{K_2O} \xrightarrow{heating} \underset{(Yellow)}{K_2O}$ $K_2O + H_2O \longrightarrow 2KOH$

Name of compound	Name and Brief about the process	Related chemical reaction
K_2O_2 (Potassium peroxide)	By burning potassium at 300°C in a limited supply of air or oxygen.	$2K + O_2 \xrightarrow[air\ at\ 300^\circ C]{Controlled} K_2O_2$

Name of compound	Name and Brief about the process	Related chemical reaction
KO_2 (Potassium superoxide)	Pas (i) Passage of O_2 through a blue solution of K in liquid NH_3 yields oxides K_2O_2 (white), K_2O_3 (red) and KO_2 (deep yellow) i.e KO_2 reacts with H_2O and produces H_2O_2 and O_2 both.	K in liq. $NH_3 \xrightarrow{O_2} \underset{white}{K_2O_2} \longrightarrow \underset{red}{K_2O_3} \longrightarrow \underset{yellow}{KO_2}$ $2KO_2 + 2H_2O \xrightarrow{\sim 0^\circ C} 2KOH + H_2O_2 + O_2$
	(ii) It is prepared by burning potassium in excess of oxygen free from moisture.	$K + O_2 \longrightarrow KO_2$

Name of compound	Name and Brief about the process	Related chemical reaction
K_2O_3 (Potassium sesquioxide)	It is obtained when oxygen is passed through liquid ammonia containing potassium.	4K (dissolved in liquid NH_3) $\xrightarrow{3O_2}$ $2K_2O_3$

Name of compound	Name and Brief About the process	Related chemical reaction
KO_3 (Potassium ozonide)	From KOH	$\underset{(Dry\ powdered)}{KOH}$ + O_3 (ozonised oxygen) $\xrightarrow{-10^\circ to -15^\circ C}$ $\underset{(orange\ solid)}{KO_3}$

Properties of Potassium superoxide (KO_2)

It is a orange coloured (chrome yellow) powder and reacts with water according to following reaction.

$$2KO_2 + 2H_2O \longrightarrow 2KOH + H_2O_2 + O_2$$

It reacts directly with CO and CO_2.

$$2KO_2 + CO \longrightarrow K_2CO_3 + O_2\ ;\ 2KO_2 + CO_2 \longrightarrow K_2CO_3 + O_2$$

If more CO_2, in presence of moisture is present; then

$$4KO_2 + 4CO_2 + 2H_2O \longrightarrow 4KHCO_3 + 3O_2$$

On heating with sulphur, it forms potassium sulphate

$$2KO_2 + S \longrightarrow K_2SO_4$$

Uses : It is used as an oxidising agent and air purifier in space capsules, submarine and breathing mask as it produces O_2 and removes CO_2.

4. Magnesium Oxide (MgO):

Name of compound	Name and Brief about the process	Related chemical reaction
Magnesium Oxide (MgO)	It is also called magnesia and obtained by heating natural magnesite.	$MgCO_3 \longrightarrow MgO + CO_2$

Properties :

(1) It is white powder.

(2) It's m.p. is 2850°C. Hence used in manufacture of refractory bricks for furances. And it is acts as basic flux and facilitates the removal of acidic impurities of Si, P and S from steel through slag formation.

(3) It is very slightly soluble in water imparting alkaline reaction.

5. Calcium Oxide (CaO):

Preparation

Name of compound	Name and Brief about the process	Related chemical reaction
Calcium Oxide (CaO)	It is commonly called as quick lime or lime and made by decomposing lime stone at a high temperature about 1000°C.	$CaCO_3 \overset{\Delta}{\rightleftharpoons} CaO + CO_2$

* *The Carbon dioxide is removed as soon as it is produced to enable the reaction to proceed to completion.*

Chemical Properties :

(1) It is white amorphous powder of m.p. 2570°C. On exposure to atmosphere; it absorbs moisture and carbondioxide.

$$CaO + H_2O \longrightarrow Ca(OH)_2 \quad ; \quad CaO + \underset{\text{acidic oxide}}{CO_2} \longrightarrow CaCO_3$$

(2) It emits intense light (lime light), when heated in oxygen-hydrogen flame.

(3) It combines with limited amount of water to produce slaked lime. This process is called slaking of lime. Quick lime slaked with soda gives solid sodalime (CaO). Being a basic oxide.

$$CaO + H_2O \longrightarrow Ca(OH)_2$$

(4) Soda lime (basic oxide) combines with some acidic oxides at high temperature.

$$CaO + SiO_2 \longrightarrow CaSiO_3$$
$$6CaO + P_4O_{10} \longrightarrow 2Ca_3(PO_4)_2$$

Uses :

(i) It is an important primary material for manufacturing cement and is the cheapest form of alkali.

(ii) It is used in the manufacture of sodium carbonate from caustic soda.

(iii) It is employed in the purification of sugar and in the manufacture of dye stuffs.

Magnesium Peroxide (MgO_2) and Calcium Peroxide (CaO_2)

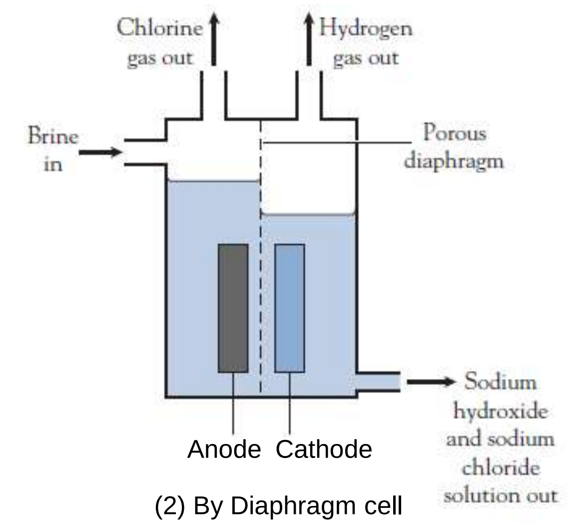
These are obtained by passing H_2O_2 in a suspension of $Mg(OH)_2$ and $Ca(OH)_2$.

Uses : MgO_2 is used as an antiseptic in tooth paste and as a bleaching agent.

HYDROXIDES

1. Sodium Hydroxides(Caustic Soda) NaOH (White) :

Preparation :

Name of compound	Name and Brief about the process	Related chemical reaction
Sodium Hydroxides (NaOH)	**(1) Electrolysis of Brine :** Sodium hydroxide is prepared by the electrolysis of sodium chloride in Castner-Kellner cell. A brine solution is electrolysed using a mercury cathode and a carbon anode. Sodium metal discharged at the cathode combines with mercury to form sodium amalgam. Chlorine gas is evolved at the anode. The amalgam is treated with water to give sodium hydroxide and hydrogen gas.	Cathode: $Na^+ + e^- \xrightarrow{Hg}$ Na-amalgam Anode : $Cl^- \longrightarrow \frac{1}{2}Cl_2 + e^-$ 2Na-amalgam + $2H_2O \longrightarrow 2NaOH + 2Hg + H_2$  (2) By Diaphragm cell
	(3) Caustication of Na_2CO_3 **(Gossage's method)**	$Na_2CO_3 + Ca(OH)_2 \longrightarrow 2NaOH + \underset{\text{(suspension)}}{CaCO_3\downarrow}$ Since the $K_{sp}(CaCO_3) < K_{sp}(Ca(OH)_2)$, the reaction shifts towards right.

Properties:

(1) Sodium hydroxide is a white, translucent solid. It melts at 591 K. It is readily soluble in water to give a strong alkaline solution. Crystals of sodium hydroxide are deliquescent. The sodium hydroxide solution at the surface reacts with the CO_2 in the atmosphere to form Na_2CO_3.

(2) It is white crystalline, deliquescent, highly corrosive solid.

(3) It is stable towards heat.

(4) It's aqueous solution alkaline in nature and soapy in touch.

(5)
$$NH_4Cl + NaOH \longrightarrow NaCl + NH_3\uparrow + H_2O$$
$$FeCl_3 + 3NaOH \longrightarrow \underset{\text{Brown ppt}}{Fe(OH)_3\downarrow} + 3NaCl$$
$$ZnCl_2 + 2NaOH \longrightarrow Zn(OH)_2\downarrow + 2NaCl$$
$$Zn(OH)_2\downarrow + 2NaOH \longrightarrow \underset{\text{soluble}}{Na_2ZnO_2} + 2H_2O \text{ [Same with } AlCl_3, SnCl_2, PbCl_2]$$

(6) Acidic and amphoteric oxides gets dissolved easily e.g.
$$CO_2 + 2NaOH \longrightarrow Na_2CO_3 + H_2O$$
$$Al_2O_3 + 2NaOH \longrightarrow 2NaAlO_2 + H_2O$$

(7) Aluminium and Zn metal gives H_2 from NaOH.
$$2Al + 2NaOH + 2H_2O \longrightarrow 3H_2 + 2NaAlO_2$$

(8) Several non metals such as P, S, Cl etc. yield a hydride instead of hydrogen.e.g.
$$4P + 3NaOH + 3H_2O \longrightarrow PH_3 + 3NaH_2PO_2 \text{ (Disproportionation reaction)}$$

(9) NaOH is stable towards heat but reduced to metal when heated with carbon.
$$2NaOH + C \longrightarrow 2Na + 2\,CO + H_2$$

(10). NaOH + Metal Oxide (M)
$$\xrightarrow{+2} Na_2MO_2$$
$$\xrightarrow{+3} Na_3MO_3$$
$$\xrightarrow{+4} Na_2MO_3$$

Above are general reactions of NaOH with metal oxides having metal's Oxidation number +2, +3 & +4 respectively.

<u>Uses</u> : It is used in

(i) The manufacture of soap, paper, artificial silk and a number of chemicals.

(ii) In petroleum refining.

(iii) In the purification of bauxite.

(iv) In the textile industries for mercerising cotton fabrics.

(v) For the preparation of pure fats and oils .

(vi) As a laboratory reagent.

2. Potassium Hydroxide (KOH):

Preparation:

(1) It is prepared by electrolysis of KCl solution.

(2) KOH resembles NaOH in all its reactions. However KOH is much more soluble in alcohol. This accounts for the use of alcoholic KOH in organic chemistry.

(3) KOH is called caustic potash, because of their corrosive properties (for example on glass or on skin) and its aqueous solution is known as **potash lye**.
$$2KOH + 4NO \longrightarrow 2KNO_2 + N_2O + H_2O$$
$$4KOH + 6NO \longrightarrow 4KNO_2 + N_2 + 2H_2O$$

(4) It is used for the absorption of gases like CO_2, SO_2, etc. It is used for making soft soaps.

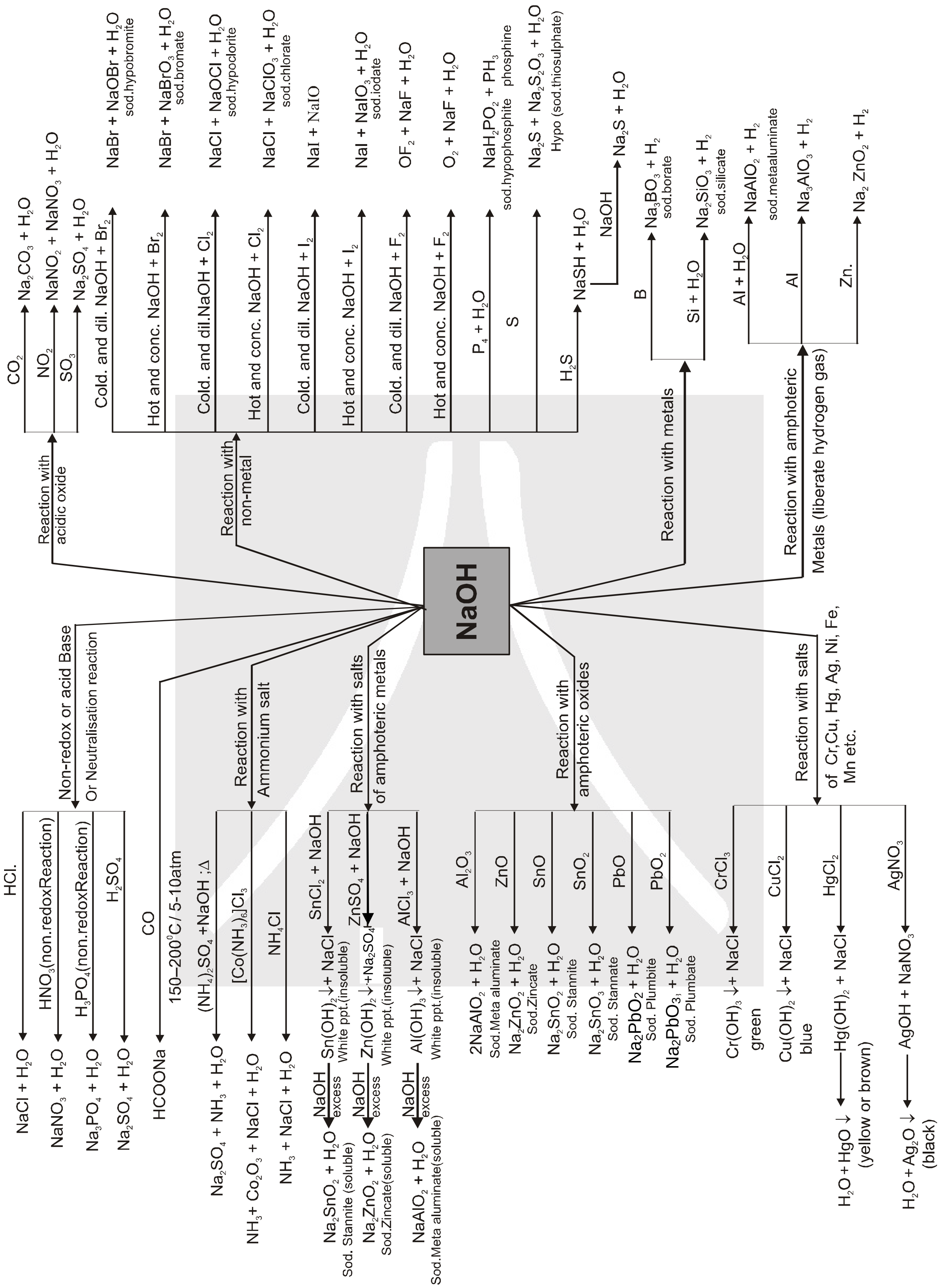
Properties: Same as NaOH

(1) It is stronger base compared to NaOH.

(2) Solubility in water is more compared to NaOH.

(3) In alcohol, NaOH is sparingly soluble but KOH is highly soluble.

(4) As a reagent KOH is less frequently used but in absorption of CO_2, KOH is preferably used compared to NaOH. Because $KHCO_3$ formed is soluble whereas $NaHCO_3$ is insoluble and may therefore choke the tubes of apparatus used.


NaOH
Reaction with acidic oxide
CO_2 → $Na_2CO_3 + H_2O$
NO_2 → $NaNO_2 + NaNO_3 + H_2O$
SO_3 → $Na_2SO_4 + H_2O$
Reaction with non-metal
Cold. and dil. NaOH + Br_2 → NaBr + NaOBr + H_2O sod.hypobromite
Hot and conc. NaOH + Br_2 → NaBr + $NaBrO_3$ + H_2O sod.bromate
Cold. and dil.NaOH + Cl_2 → NaCl + NaOCl + H_2O sod.hypoclorite
Hot and conc. NaOH + Cl_2 → NaCl + $NaClO_3$ + H_2O sod.chlorate
Cold. and dil. NaOH + I_2 → NaI + NaIO
Hot and conc. NaOH + I_2 → NaI + $NaIO_3$ + H_2O sod.iodate
Cold. and dil. NaOH + F_2 → OF_2 + NaF + H_2O
Hot and conc. NaOH + F_2 → O_2 + NaF + H_2O
$P_4 + H_2O$ → $NaH_2PO_2 + PH_3$ sod.hypophosphite phosphine
S → $Na_2S + Na_2S_2O_3 + H_2O$ Hypo (sod.thiosulphate)
H_2S → NaSH + H_2O NaOH → $Na_2S + H_2O$
Reaction with metals
B → $Na_3BO_3 + H_2$ sod.borate
Si + H_2O → $Na_2SiO_3 + H_2$ sod.silicate
Reaction with amphoteric Metals (liberate hydrogen gas)
Al + H_2O → $NaAlO_2 + H_2$ sod.metaaluminate
Al → $Na_3AlO_3 + H_2$
Zn. → $Na_2ZnO_2 + H_2$
Non-redox or acid Base Or Neutralisation reaction
HCl. → NaCl + H_2O
HNO_3(non.redoxReaction) → $NaNO_3 + H_2O$
H_3PO_4(non.redoxReaction) → $Na_3PO_4 + H_2O$
H_2SO_4 → $Na_2SO_4 + H_2O$
CO 150–200^{0}C / 5-10atm → HCOONa
Reaction with Ammonium salt
$(NH_4)_2SO_4$ +NaOH ;Δ → $Na_2SO_4 + NH_3 + H_2O$
$[Co(NH_3)_6]Cl_3$ → $NH_3 + Co_2O_3$ + NaCl + H_2O
NH_4Cl → NH_3 + NaCl + H_2O
Reaction with salts of amphoteric metals
$SnCl_2$ + NaOH → $Sn(OH)_2$↓+ NaCl White ppt.(insoluble) → NaOH excess → $Na_2SnO_2 + H_2O$ Sod. Stannite (soluble)
$ZnSO_4$ + NaOH → $Zn(OH)_2$↓+Na_2SO_4 White ppt.(insoluble) → NaOH excess → $Na_2ZnO_2 + H_2O$ Sod.Zincate(soluble)
$AlCl_3$ + NaOH → $Al(OH)_3$↓+ NaCl White ppt.(insoluble) → NaOH excess → $NaAlO_2 + H_2O$ Sod.Meta aluminate(soluble)
Reaction with amphoteric oxides
Al_2O_3 → $2NaAlO_2 + H_2O$ Sod.Meta aluminate
ZnO → $Na_2ZnO_2 + H_2O$ Sod.Zincate
SnO → $Na_2SnO_2 + H_2O$ Sod. Stannite
SnO_2 → $Na_2SnO_3 + H_2O$ Sod. Stannate
PbO → $Na_2PbO_2 + H_2O$ Sod. Plumbite
PbO_2 → $Na_2PbO_3 + H_2O$ Sod. Plumbate
Reaction with salts of Cr,Cu, Hg, Ag, Ni, Fe, Mn etc.
$CrCl_3$ → $Cr(OH)_3$↓+ NaCl green
$CuCl_2$ → $Cu(OH)_2$↓+ NaCl blue
$HgCl_2$ → $Hg(OH)_2$ + NaCl → H_2O + HgO↓ (yellow or brown)
$AgNO_3$ → AgOH + $NaNO_3$ → $H_2O + Ag_2O$↓ (black)

3. Magnesium Hydroxide ($Mg(OH)_2$):

It occurs in nature as the mineral brucite.

Preparation:

Name of compound	Name and Brief about the process	Related chemical reaction
Magnesium Hydroxide ($Mg(OH)_2$)	It can be prepared by adding caustic soda solution to a solution of Magnesium sulphate or chloride solution.	$MgSO_4 + 2NaOH \longrightarrow Mg(OH)_2 + Na_2SO_4$ $MgCl_2 + 2NaOH \longrightarrow Mg(OH)_2 + 2NaCl$ $MgCl_2 + Ca(OH)_2 \longrightarrow Mg(OH)_2 + CaCl_2$ $MgO + H_2O \longrightarrow Mg(OH)_2$

Chemical Properties:

(1) It can be dried at temperature upto 100°C only otherwise it breaks into its oxide at higher temperature.

$$Mg(OH)_2 \longrightarrow MgO + H_2O$$

(2) It is slightly soluble in water imparting alkalinity.

(3) It dissolves in NH_4Cl solution.

$$Mg(OH)_2 + 2NH_4Cl \longrightarrow MgCl_2 + 2NH_3.H_2O$$

Thus, $Mg(OH)_2$ is not therefore precipitated from a solution of Mg^{2+} ions by $NH_3.H_2O$. in presence of excess of NH_4Cl.

Uses : A suspension of $Mg(OH)_2$ in water is used in medicine as an **antacid** (An antacid is substance which neutralizes stomach acidity) under the name, **milk of magnesia.**

4. Calcium Hydroxide ($Ca(OH)_2$) (White Powder):

Preparation :

Name of compound	Name and Brief about the process	Related chemical reaction
Calcium Hydroxide ($Ca(OH)_2$)	By spraying water on quicklime.	$CaO + H_2O \longrightarrow Ca(OH)_2$

Properties:

(1) It is a white amorphous powder.

(2) It is sparingly soluble in water.

(3) It's solubility in hot water is less than that of cold water. Hence solubility decreases with increase in temperature.

(4) The aqueous solution is known as lime water and a suspension of slaked lime in water is known as milk of lime.

(5) When carbon dioxide is passed through lime water it turns milky due to the formation of calcium carbonate.

$$Ca(OH)_2 + CO_2 \longrightarrow CaCO_3 + H_2O$$

On passing excess of carbon dioxide, the precipitate dissolves to form calcium hydrogen carbonate.

$$CaCO_3 + CO_2 + H_2O \longrightarrow Ca(HCO_3)_2$$

Milk of lime reacts with chlorine to form hypochlorite, a constituent of bleaching powder.

$$2Ca(OH)_2 + 2Cl_2 \longrightarrow CaCl_2 + \underset{\text{Bleaching powder}}{Ca(OCl)_2} + H_2O$$

Uses:

(i) It is used in the preparation of mortar, a building material.

(ii) It is used in white wash due to its disinfectant nature.

(iii) It is used in glass making, in tanning industry, for the preparation of bleaching powder and for purification of sugar.

Section (F) : Carbonates, Bicarbonates

CARBONATES

1. Sodium Carbonate (Washing soda) $Na_2CO_3.10H_2O$ (White Solid) :

Preparation:

1.

Name of compound	Name and Brief about the process	Related chemical reaction
Sodium Carbonate (Washing soda) $Na_2CO_3.10H_2O$	(1) **Leblanc Process**	$NaCl + H_2SO_4(conc.) \xrightarrow{\text{mild heating}} NaHSO_4 + HCl$ $NaCl + NaHSO_4 \xrightarrow[\text{heated}]{\text{Strongly}} Na_2SO_4 + HCl$ (Salt Cake) $Na_2SO_4 + 4C \longrightarrow Na_2S + 4CO\uparrow$ $Na_2S + CaCO_3 \longrightarrow Na_2CO_3 + CaS$
	(2) Solvay Process Step-1 (In ammonia absorber) (i)Saturation of brine with ammonia and CO_2 (ii) Ammoniated brine is filtered to remove calcium and magnesium impurities as their insoluble carbonates.	$2NH_3 + CO_2 + H_2O \longrightarrow (NH_4)_2CO_3$ $CaCl_2 + (NH_4)_2CO_3 \longrightarrow CaCO_3\downarrow + 2NH_4Cl$ $MgCl_2 + (NH_4)_2CO_3 \longrightarrow MgCO_3\downarrow + 2NH_4Cl$
	Step-2 (In carbonation tower) : (i) Formation of insoluble $NaHCO_3$ (ii) Reaction is exothermic and hence there is a cooling arrangement. (iii) $NaHCO_3$ is insoluble in cold brine solution because of the common ion effect. It is separated by filtration and the filtered is used for recovering NH_3 & CO_2.	$NH_3 + CO_2 + H_2O \longrightarrow NH_4HCO_3$; $NH_4HCO_3 + NaCl \xrightarrow{30^\circ C} NaHCO_3 + NH_4Cl$
	Step-3 (Calcination to get sodium carbonate) :	$2\,NaHCO_3 \xrightarrow{150^\circ C} Na_2CO_3 + CO_2 + H_2O$
	Step - 4 (In recovery tower) : Recovery of ammonia and carbondioxide. $CaCl_2$ is obtained as by product.	$NH_4\,HCO_3 \xrightarrow{\Delta/\text{Steam}} NH_2 + CO_2 + H_2O$ $2NH_4\,Cl + Ca(OH)_2 \xrightarrow{\Delta/\text{Steam}} 2NH_3 + 2H_2O + CaCl_2$

* advantage is taken of low solubility of $NaHCO_3$, it gets precipitated in the reaction of $NaCl + NH_4HCO_3$.

2. Naturally from trona

$$2(Na_2CO_3.NaHCO_3.2H_2O) \xrightarrow{\text{heat}} 3Na_2CO_3 + CO_2 + 5H_2O$$

Properties

(1) Anhydrous Na_2CO_3 is called as soda ash, which does not decompose on heating but melts at 852°C.

(2) Sodium carbonate is a white crystalline solid which exists as a decahydrate, $Na_2CO_3\cdot10H_2O$. This is also called washing soda. It is readily soluble in water. On heating, the decahydrate loses its water of crystallisation to form monohydrate. Above 373K, the monohydrate becomes completely anhydrous and changes to a white powder called soda ash.

$$Na_2CO_3\cdot10H_2O \xrightarrow{375K} Na_2CO_3\cdot H_2O + 9H_2O$$

$$Na_2CO_3\cdot H_2O \xrightarrow{>373K} \underset{\text{(soda ash)}}{Na_2CO_3} + H_2O$$

Carbonate part of sodium carbonate gets hydrolysed by water to form an alkaline solution.

$$Na_2CO_3 + H_2O \longrightarrow H_2CO_3\,\text{(weak acid)} + NaOH\,\text{(strong)}$$

(3) Na_2CO_3 absorbs CO_2 yielding sparingly soluble sodium bicarbonate which can be calcined at 250° to get pure sodium carbonate.

$$Na_2CO_3 + H_2O + CO_2 \underset{250^\circ C}{\rightleftharpoons} 2NaHCO_3\,\text{(solid)}$$

(4) It dissolved in acid with effervescence of CO_2 and causticised by lime to give caustic soda.

$$Na_2CO_3 + HCl \longrightarrow 2NaCl + H_2O + CO_2$$

$$Na_2CO_3 + Ca(OH)_2 \longrightarrow 2NaOH + CaCO_3$$

Uses :

(i) It is used in water softening, laundering and cleaning.

(ii) It is used in the manufacture of glass, soap, borax and caustic soda.

(iii) It is used in paper, paints and textile industries.

(iv) It is an important laboratory reagent both in qualitative and quantitative analysis.

2. Potassium Carbonate (K_2CO_3)

Name of compound	Name and Brief about the process	Related chemical reaction
Potassium Carbonate (K_2CO_3)	By **leblance process**, it can be prepared but by **solvay process** it **cannot be prepared** because $KHCO_3$ is soluble in water.	$KCl + H_2SO_4 \text{ (conc.)} \xrightarrow{\text{mild heating}} KHSO_4 + HCl$ $KCl + KHSO_4 \xrightarrow[\text{heated}]{\text{Strongly}} K_2SO_4 + HCl$ $K_2SO_4 + 4C \longrightarrow K_2S + 4CO\uparrow$ $K_2S + CaCO_3 \longrightarrow K_2CO_3 + CaS$

Properties:
It resembles with Na_2CO_3, m.p. is 900°C but a mixture of Na_2CO_3 and K_2CO_3 melts at 712°C.

Uses It is used in glass manufacturing.
** need not memories.*

Note : Calcium carbonate and Magnesium carbonate found in nature.
Calcium bicarbonate and Magnesium bicarbonate are present in temporary hardness of water.
Unstable and unimportant. Same for $KHCO_3$.

Section (G) : Chlorides, Sulphates

CHLORIDES

Sodium Chloride (NaCl) and Potassium Chloride, Calcium Chloride
Preparation:
NaCl : Found in nature as rock salt or in sea water.
KCl : Found in nature as sylvine (KCl) or carnallite ($2KCl.MgCl_2.6H_2O$)
$CaCl_2$: Obtained as byproduct in Solvay's process.

Properties of NaCl :
(1) It is nonhygroscopic but the presence of $MgCl_2$ in common salt renders it hygroscopic.
(2) It is used to prepare freezing mixture in laboratory [Ice-common salt mixture is called freezing mixture and temperature goes down to –23°C.]
(3) For melting ice and snow on road.

Uses of NaCl:
(i) It is used as a common salt or table salt for domestic purpose.
(ii) It is used for the preparation of Na_2O_2, NaOH and Na_2CO_3.

Magnesium Chloride ($MgCl_2$)
It occurs in nature as mineral carnallite, $KCl.MgCl_2.6H_2O$.

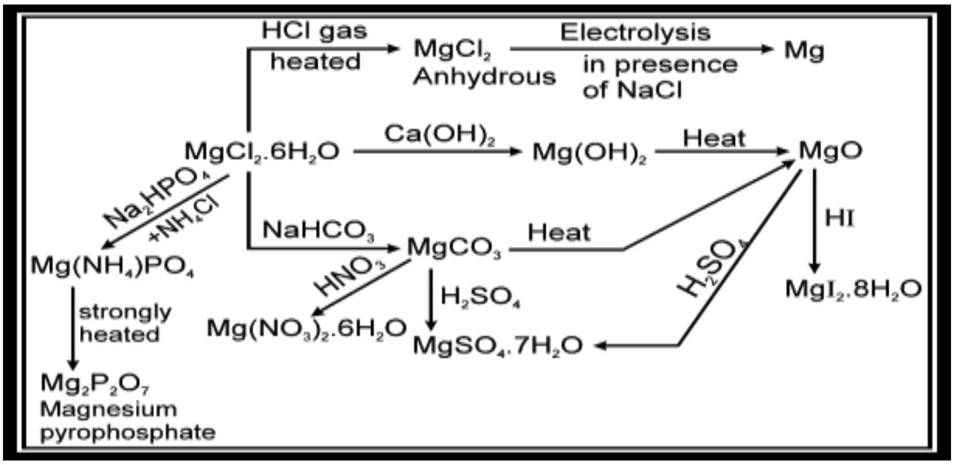
Preparation : By **Dow's Processes** (Natural Brine process and Dolomite process). See Metallurgy, stdXII.
Properties:
(1) It crystallises as hexahydrate. $MgCl_2.\ 6H_2O$
(2) It is deliquescent solid.
(3) This hydrate undergoes hydrolysis as follows:

$$MgCl_2{\cdot}6H_2O \longrightarrow Mg(OH)Cl + HCl + 5H_2O$$
$$Mg(OH)Cl \longrightarrow MgO + HCl$$

Hence, Anh. $MgCl_2$ cannot be prepared by heating this hydrate. Because of this formation of HCl. Sea water cannot be used in marine boilers which corrodes the iron body.
(4) Anhydrous $MgCl_2$ can be prepared by heating a double salt like. $MgCl_2.NH_4Cl.6H_2O$ as follows:

$$MgCl_2\ .\ NH_4Cl\ .\ 6H_2O \xrightarrow[\Delta]{-H_2O} MgCl_2.\ NH_4Cl \xrightarrow[\Delta]{\text{strong}} MgCl_2 + NH_3 + HCl$$

(5) It is a colourless crystalline solid, highly deliquescent and highly soluble in water.
(6) **Sorel Cement** is a mixture of MgO and $MgCl_2$ (paste like) which set to hard mass on standing. This is used in dental filling, flooring etc.
(7) Anh. $CaCl_2$ is used in drying gases and organic compounds but not NH_3 or alcohol due to the formation of $CaCl_2.8NH_3$ and $CaCl_2.4C_2H_5OH$.



SULPHATES

1. Potassium Sulphate (K_2SO_4)

It occurs in stassfurt potash beds as schonite $K_2SO_4.MgSO_4.6H_2O$ and Kainite, $KCl.MgSO_4.3H_2O$ from which it is obtained by solution in water and crystallisation. It separates from the solution as anh, crystals whereas Na_2SO_4 comes as decahydrate.

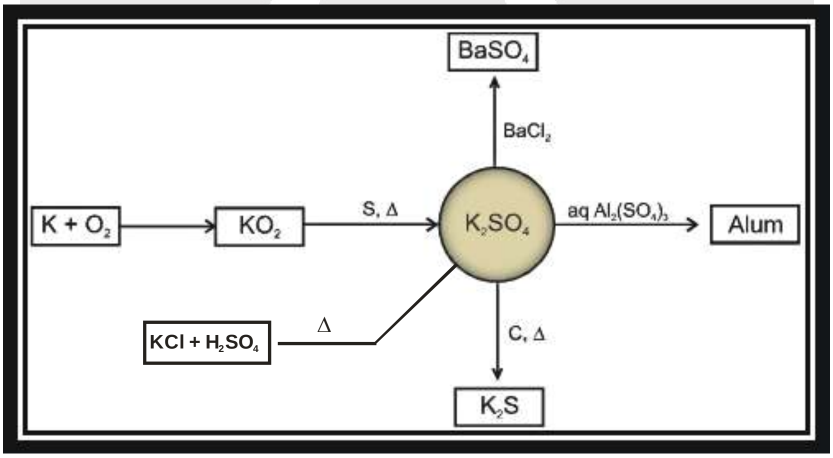
Preparation:

(1) It is prepared by the reaction of potassium chloride or hydroxide with concentrated. H_2SO_4.

$$2KCl + H_2SO_4 \longrightarrow K_2SO_4 + 2HCl \ ; \ 2KOH + H_2SO_4 \longrightarrow K_2SO_4 + 2H_2O$$

(2) $K_2SO_4.MgSO_4.6H_2O + 2KCl \longrightarrow 2K_2SO_4 + MgCl_2 + 6H_2O$

Uses : It is used to prepare alum.
It is a white crystalline solid and soluble in water.
It is used as a fertilizer for tobacco and wheat.



Reactions Charts

2. Magnesium Sulphate ($MgSO_4$):

It occurs in nature as minerals kiesserite ($MgSO_4.H_2O$), epsom salt ($MgSO_4.7H_2O$) and kainite ($KCl.MgSO_4.3H_2O$).

Preparation:

(1) It is obtained by dissolving kieserite. $MgSO_4.H_2O$ in boiling water and then crystallising the solution as a hepta hydrate. i.e. $MgSO_4.7H_2O$. It is called as Epsom salt.

(2) It is also obtained by dissolving magnesite in hot dil. H_2SO_4.

$$MgCO_3 + H_2SO_4 \longrightarrow MgSO_4 + H_2O + CO_2$$

(3) By dissolving dolomite ($CaCO_3.MgCO_3$) in hot dil. H_2SO_4 and removing the insoluble $CaSO_4$ by filtration.

$$CaCO_3.MgCO_3 \text{ (dolomite)} + 2H_2SO_4 \longrightarrow MgSO_4 + CaSO_4 + 2CO_2 + 2H_2O$$

(4) It is isomorphous with $FeSO_4.7H_2O$, $ZnSO_4.7H_2O$.

Chemical Properties:

Heating effect:

(1) When heated to 150°C, it changes to monohydrate. On further heating, it becomes anhydrous at 200°C. On strong heating, it decomposes into MgO.

$$MgSO_4.7H_2O \xrightarrow{150°C} MgSO_4.H_2O \xrightarrow{200°C} MgSO_4 \xrightarrow[heating]{strong} MgO + SO_2 + O_2.$$

(2) Magnesium sulphate when heated with lamp black at 800°C produces SO_2 and CO_2 gases.

$$2MgSO_4 + C \longrightarrow 2MgO + 2SO_2 + CO_2$$

(3) It forms double salts with alkali metal sulphates, e.g., $K_2SO_4.MgSO_4.6H_2O$.

3. Calcium Sulphate (Plaster of paris) $CaSO_4.½\ H_2O$

It occurs as anhydrite $CaSO_4$, hemihydrate $CaSO_4.½H_2O$ and as the dihydrate ($CaSO_4.2H_2O$) gypsum, alabaster or satin-spar.

Preparation:

(1) It is a hemihydrate of calcium sulphate. It is obtained when gypsum, $CaSO_4{\cdot}2H_2O$, is heated to 393 K.

$$2(CaSO_4.2H_2O) \xrightarrow{393\,K} 2(CaSO_4).H_2O + 3H_2O$$

Above 393 K, no water of crystallisation is left and anhydrous calcium sulphate, $CaSO_4$ is formed. This is known as 'dead burnt plaster'.

It has a remarkable property of setting with water. On mixing with an adequate quantity of water it forms a plastic mass that gets into a hard solid in 5 to 15 minutes.

(2) It can be prepared by reacting any calcium salt with either sulphuric acid or a soluble sulphate.

$$CaCl_2 + H_2SO_4 \longrightarrow CaSO_4 + 2HCl\ ; \qquad CaCl_2 + Na_2SO_4 \longrightarrow CaSO_4 + 2NaCl$$

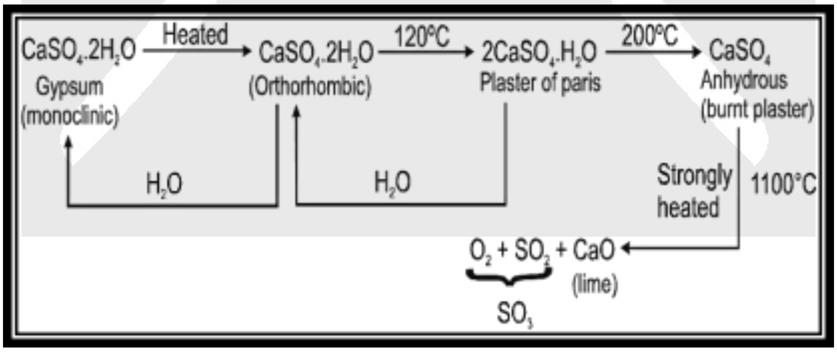
Properties:

It is a white crystalline solid. It is sparingly soluble in water and solubility decreases as temperature increases.

It dissolves in dilute acids. It also dissolves in ammonium sulphate due to the formation of double sulphate, $(NH_4)_2SO_4.CaSO_4.H_2O$.

The setting process is **exothermic**. The process of setting takes place in stages. In the first stage, there is conversion of Plaster of Pairs into orthorhombic form of gypsum (setting step) and in the second stage orthorhombic form changes into monoclinic form (hardening step).

The setting of Plaster of Paris may be **catalysed by sodium chloride** while it is retarded by borax or alum. Addition of alum to Plaster of Paris makes the setting very hard. The mixture is known as **Keene's cement**.



Dead plaster has no setting property as it takes up water only very slowly.

A suspension of gypsum when saturated with ammonia and carbon dioxide forms ammonium sulphate, a nitrogenous fertilizer.

$$2NH_3 + CaSO_4 + CO_2 + H_2O \longrightarrow (NH_4)_2 SO_4 + CaCO_3$$

When strongly heated with carbon, it forms calcium sulphide.

$$CaSO_4 + 4C \longrightarrow CaS + 4CO$$

Uses: For preparing blackboard chalk.

In anhydrous form as drying agent.

Fertilizer

1. **Cynamide:** It is an organic compound with the formula CN_2H_2. This white solid is widely used in agriculture and the production of pharmaceuticals and other organic compounds.
Cyanamide is produced by hydrolysis of calcium cyanamide, which in turn is prepared from calcium carbide via the frank-Caro process.

$$CaC_2 + N_2 \longrightarrow CaCN_2 + C \text{ ; frank-Caro process}$$
$$CaCN_2 + H_2O + CO_2 \longrightarrow CaCO_3 + H_2NCN \text{ (Cynamide)}$$

The main reaction exhibited by cyanamide involves additions of compounds containing an acidic proton. Water, hydrogen sulfide, and hydrogen selenide react with cyanmide to give urea, thiourea, and selenourea, respectively :

$$H_2NCN + H_2E \rightarrow H_2NC(E)NH_2 \text{ ; (E= O, S, Se)}$$

2. **Fluorapatite:** It is a phosphate mineral with the formula $Ca_5(PO_4)_3$.

Cement

Cement is a product obtained by combining a material rich in lime, CaO with other material such as clay which contains silica, SiO_2 along with the oxides of aluminium, iron and magnesium.
The raw materials for the manufacture of cement are limestone and clay. When clay and lime are strongly heated together they fuse and react to form cement clinker. This clinker is mixed with 2-3% by weight of gypsum ($CaSO_4.2H_2O$) to form cement. Thus important ingredients present in Portland cement are dicalcium silicate (Ca_2SiO_4) 26%, tricalcium silicate (Ca_3SiO=5) 51% and tricalcium aluminate ($Ca_3Al_2O_6$) 11%.
Setting of cement : When mixed with water, the setting of cement takes place to give a hard mass. This is due to the hydration of the molecules of the constituents and their rearrangement. The purpose of adding gypsum is only to slow down the process of setting of the cement so that it gets sufficiently hardened.
Uses : Cement has become a commodity of national necessity for any country next to iron and steel. It is used in concrete and reinforced concrete, in plastering and in the construction of bridges, dams and buildings.

Common Names

The names marked with asterisk (*) should be memorized with formulae. Others are given only for reference. You need not memorize them.

Metal	Ore name	Formula
Lithium (Li)	Spodumene	$LiAl(SiO_3)_2$
	Lepidolite	$KLi_2Al(Al,Si)_3O_{10}(F,OH)_2$
	Petalite	$LiAl(Si_2O_5)_2$
Sodium (Na)	*Washing soda	$Na_2CO_3.10H_2O$
	*Baking soda	$NaHCO_3$
	*Sodium carbonate (soda ash/ washing soda)	Na_2CO_3
	*Sodium chloride (rock salt or halite)	NaCl
	*Sodium nitrate (Chile saltpeter)	$NaNO_3$
	Salt cake	Na_2SO_4
	Fusion mixture	$Na_2CO_3 + K_2CO_3$ (eq. molar mix.)
	Sodium sesquicarbonate (trona)	$Na_2CO_3.NaHCO_3.2H_2O$ (it is a double salt)
	*Microcosmic salt	$Na(NH_4)HPO_4.4H_2O$ (it is obtained by mixing solutions of sodium phosphate and ammonium phosphate or chloride)
	Soda feldspar or sodium feldspar (albite)	$Na_2O. Al_2O_3. 6SiO_2$
	Potash feldspars or orthoclase or microcline or Potassium feldspars	$K_2O. Al_2O_3.6SiO_2$
	*Hypo	$Na_2S_2O_3.5H_2O$
	*Sodium aluminium fluoride (cryolite)	Na_3AlF_6
	*Borax (Tincal)	$Na_2B_4O_7.10H_2O$

	*Sodium sulphate (glauber's salt)	$Na_2SO_4.10H_2O$ (**Sodium sulfate** is the sodium salt of sulfuric acid. When anhydrous, it is a white crystalline solid of formula Na_2SO_4 known as the mineral thenardite; the decahydrate $Na_2SO_4·10H_2O$ is known as **Glauber's salt**)
	Sodium aluminium silicate (Soda Feldspar)	$NaAlSi_3O_8$
Potassium (K)	Sylvite	KCl
	Schonite	$K_2SO_4.MgSO_4.6H_2O$
	Kainite	$MgSO_4.KCl.3H_2O$
	*Carnallite	$MgCl_2.KCl.6H_2O$
	*Indian saltpetre (Nitre)	KNO_3 (used especially as a fertilizer and explosive)
	Pearl ash	K_2CO_3
	Schonite	$K_2SO_4.MgSO_4.6H_2O$(it is a double salt)
	Langbeinite	$K_2SO_4.2MgSO_4$
	Polyhalite	$K_2SO_4.MgSO_4.2CaSO_4.2H_2O$
	*Potassium Alum	$K_2SO_4.\ Al_2\ (SO_4)_3.\ 24H_2O$
	Alunite or Alumstone	$K_2SO_4.\ Al_2\ (SO_4)_3.\ 4Al(OH)_3$
	Mica	$K_2O.\ 3Al_2O_3.\ 6SiO_2.2H_2O$
	Feldspar	$KAlSi_3O_8(K_2O.Al_2O_3.6SiO_2)$
Beryllium (Be)	Beryl	$3BeO.\ Al_2O_3\ 6SiO_2$
	Chrysoberyl	$BeO.Al_2O_3$
	Phenacite	$BeSiO_4$
	Bromalite	BeO
	*Baryta	$Ba(OH)_2$
Magnesium (Mg)	*Magnesite	$MgCO_3$
	*Dolomite	$MgCO_3.CaCO_3$
	*Epsom salt	$MgSO_4.7H_2O$
	Kieserite	$MgSO_4.H_2O$
	Asbestos	$CaMg_3\ (SiO_3)_4$
	Talc	$Mg(Si_2O_5)_2\ Mg\ (OH)_2$
	Brucite	$Mg(OH)_2$
	*Magnesia	MgO
	Artinite	$MgCO_3.Mg(OH)_2\ .3H_2O$
	*Sorel cement (magnesia cement)	$Mg_4Cl_2(OH)_6(H_2O)_8$
Calcium (Ca)	*Quick lime	CaO
	*Slaked lime	$Ca(OH)_2$
	*Hydrolith	CaH_2
	*Calcium cynamide	$CaCN_2$ OR CaNCN
	*Limestone (Marble / Whiting)	$CaCO_3$
	Anhydrite	$CaSO_4$
	*Gypsum	$CaSO_4.2H_2O$
	*Fluorspar or Fluorite	CaF_2
	Phosphorite	$Ca_3\ (PO_4)_2$
	*Fluorapatite	$3Ca_3\ (PO_4)_2.CaF_2$ OR $Ca_5(PO_4)_3F$
	*Plaster of paris	$CaSO_2.½H_2O$
	*Bleaching powder	$CaOCl_2$
	*Rock phosphate	$Ca_3\ (PO_4)\ _2$
	Wollastonite	$CaSiO_2$
	Colmanite	$2CaO.3Ba_2O_3.5H_2O$
Strontium(Sr)	Strontianite	$SrCO_3$
	Celestite	$SrSO_4$
	Barytes or Heavy spar	$BaSO_4$

Periodic Properties of s-Block

Properties	Order
Thermal stability	LiH > NaH > KH > RbH > CsH
Basic strength	BeO < MgO < CaO < SrO
Basic Strength or Solubility in water or thermal stability	LiOH < NaOH < KOH < RbOH < CsOH
Basic Strength or Solubility in water	$Be(OH)_2 < Mg(OH)_2 < Ca(OH)_2 < Ba(OH)_2$
Thermal stability	$Be(OH)_2 < Mg(OH)_2 < Ca(OH)_2 < Sr(OH)_2 < Ba(OH)_2$
Solubility in water or thermal stability	$Li_2CO_3 < Na_2CO_3 < K_2CO_3 < Rb_2CO_3 < Cs_2CO_3$
Solubility in water	$BaCO_3 < CaCO_3 < MgCO_3 < BeCO_3$
Thermal stability	$BeCO_3 < MgCO_3 < CaCO_3 < BaCO_3$
Solubility in water	$BaSO_4 < SrSO_4 < CaSO_4 < MgSO_4 < BeSO_4$

Exercise-1

Marked Questions may have for Revision Questions.

PART - I : SUBJECTIVE QUESTIONS

Section (A) : General facts about elements

A-1. Why do alkali metals form unipositive ions and impart characteristic colours to flame?

Section (B) : Based on Periodic trends

B-1. **(a)** Explain why is sodium less reactive than potassium?
(b) IE_1 value of Mg is more than that of Na while it's IE_2 value is less. Explain ?

B-2. Comment on the order of mobilities of the alkali metal ions in aqueous solution :
$Li^+ < Na^+ < K^+ < Rb^+ < Cs^+$.

Section (C) : Based on Chemical Bonding

C-1. Why is KO_2 paramagnetic ?

C-2. Draw the structure of $BeCl_2$ in solid and vapour state.

C-3. Explain why in anion of Na_2CO_3 all bond lengths are equal ?

C-4. Order of the ionic character of following :
$MgCl_2$, $MgBr_2$, MgI_2

C-5. Why $LiNO_3$ on heating shows exceptional behaviour than other elements of this group ?

C-6. Write the order of thermal stability of following :
$BeSO_4$, $MgSO_4$, $CaSO_4$, $SrSO_4$

C-7. Write the increasing order of basic strength of following :
NaOH, KOH, RbOH, CsOH

C-8. Although Ionisation potential of Li is very high, then why is it a good reducing agent ?

Section (D) : Properties of elements

D-1. Alkali metals are soft and can be cut with the help of a knife. Explain.

D-2. We know air mostly contains (O_2, N_2), What happen when group-I and group-II elements of s-block react with exess of air ?

Group-I Elements	+ O_2 (Major product)	+ N_2 (product)	Group-II Elements	+ O_2 (Major product)	+ N_2 (product)
Li	....	....	Be	....	....
Na	....	....	Mg	....	....
K	....	....	Ca	....	....
Rb	....	....	Sr	....	....
Cs	....	....	Ba	....	....

D-3. What happens when sodium and calcium metal are dropped in water ?
(a) $Na + H_2O \longrightarrow$ (b) $Ca + H_2O \longrightarrow$

D-4. (i) $M + H_2SO_4 \longrightarrow$ .... + ... (where M = group-I elements)
(ii) $M + HCl \longrightarrow$ .... + ... (where M = group-II elements)

D-5. What happen when sodium metal is dissolved in liquid ammonia?

Section (E) : Oxides, Peroxides, Super Oxides, Hydroxides

E-1. Lithium forms monoxide, sodium gives peroxide while the rest of the alkali metals form superoxide mainly when treated with excess of air. Explain.

E-2. How NaOH is commercialy prepared ? Which cell is used ?

E-3. Write the method of perparation of Na_2O_2 & KO_2 and also give their hydrolysis product ?

E-4. (a) $NaOH + HNO_3 \longrightarrow$ (b) $Li_2O + H_2SO_4 \longrightarrow$

(c) $Na_2O_2 + H_2SO_4(\text{dilute}) \xrightarrow{25^oC}$ (d) $CaO + HCl \longrightarrow$

E-5. $Ca(OH)_2$ (excess) + $H_3PO_4 \longrightarrow$

E-6. $NaOH + Al_2O_3 \longrightarrow$

E-7. $Cl_2 \longrightarrow$ $\xrightarrow{\text{+cold \& dil. NaOH}}$ Products

$\xrightarrow{\text{+hot \& conc. NaOH}}$ Products

E-8. P_4 (white) + NaOH + $H_2O \longrightarrow$

Section (F) : Carbonates, Bicarbonates

F-1. The thermal stability order of following carbonates :
$BeCO_3$, $MgCO_3$, $CaCO_3$, $SrCO_3$, $BaCO_3$

F-2. Write chemical changes of solvay process.

F-3. Na_2CO_3 + HCl (dil.) $\longrightarrow$

F-4. Write the products of the following reactions :

(a) $NaHCO_3 + H_2SO_4 \longrightarrow$ **(b)** $Na_2CO_3 + Ca(OH)_2 \longrightarrow$

(c) $NaHCO_3 + NaOH \longrightarrow$ **(d)** $2NaHCO_3 \xrightarrow[\text{Boil}]{\Delta}$

(e) $NaHCO_3 + CaCl_2 \xrightarrow{\text{room temperature}}$

Section (G) : Chlorides, Sulphates

G-1. Decreasing order of solubility in water of following sulphates :
$BeSO_4$, $MgSO_4$, $CaSO_4$, $SrSO_4$

G-2. How is $CaCl_2$ prepared ?

G-3. $CaSO_4.2H_2O \xrightarrow{120^oC,\ \Delta}$

G-4. How would you explain ?
(i) BeO is insoluble but $BeSO_4$ is soluble in water.
(ii) BaO is soluble but $BaSO_4$ is insoluble in water.

G-5. NaOCl + HOH $\longrightarrow$

G-6. $CaCl_2 + H_2SO_4$ (conc.) $\xrightarrow{\Delta}$

Section (H) : Miscellaneous (Hydrides, Carbides, Nitrates)

H-1. Write the thermal stability order of following :
LiH, NaH, KH, RbH, CsH

H-2. Write the products of the following reactions :

(a) $CaC_2 + H_2O \longrightarrow$

(b) $Mg_2C_3 + H_2O \longrightarrow$

H-3. **(i)** What happens when metal nitrate of s-block group-I (except Li) are heated ?

$2MNO_3 \xrightarrow{500^oC,\ \Delta}$ .... + ...

(ii) What happens when any metal nitrate of s-block group-II is heated ?

$M(NO_3)_2 \xrightarrow{\Delta}$ .... + ...+..........

H-4. (a) $Li_3N + H_2O \longrightarrow$ (b) $NaNH_2 + H_2O \longrightarrow$

PART - II : ONLY ONE OPTION CORRECT TYPE

Section (A) : General facts about elements

A-1. A chloride dissolves appreciably in cold water. When placed on a platinum wire in Bunsen flame, no distinctive colour is noticed. The cation of chloride is :

(A) Mg^{2+} (B) Ba^{2+} (C) Li^{+} (D) Ca^{2+}

A-2. A fire work gave bright crimson red light. It probably contained a salt of :

(A) Ca (B) Sr (C) Ba (D) Mg

Section (B) : Based on Periodic trends

B-1. Be has, as compared to Mg :

(A) less electronegativity (B) more ionisation potential

(C) larger atomic radius (D) lower melting point

B-2. The first ionisation energies of alkaline earth metal are higher than those of the alkali metals. This is because :

(A) there is increase in the nuclear charge of the alkaline earth metal

(B) there is decrease in the nuclear charge of the alkaline earth metal

(C) there is no change in the nuclear charge

(D) none of these

Section (C) : Based on Chemical Bonding

C-1. Among LiCl, RbCl, $BeCl_2$ and $MgCl_2$ the compound with greatest and least ionic character respectively are :

(A) LiCl, RbCl (B) RbCl, $BeCl_2$ (C) RbCl, $MgCl_2$ (D) $MgCl_2$, $BeCl_2$

C-2. Which of the following carbonate of alkalimetal have highest thermal stability ?

(A) Li_2CO_3 (B) Na_2CO_3 (C) K_2CO_3 (D) Rb_2CO_3

C-3. Which of the following hydroxide of alkali metal have highest thermal stability ?

(A) LiOH (B) NaOH (C) RbOH (D) CsOH

C-4. Which of the following is the strongest base ?

(A) $Ca(OH)_2$ (B) $Sr(OH)_2$ (C) $Ba(OH)_2$ (D) $Mg(OH)_2$

C-5. Which is amphoteric ?

(A) Li_2O (B) BeO (C) BaO (D) Cs_2O

C-6. Alkali metals are :

(A) good reductant (B) good oxidant (C) Both of these (D) None of these

Section (D) : Properties of elements

D-1. The metallic lustre exhibited by sodium is explained by :

(A) diffusion of sodium ions (B) oscillation of mobile valence electrons

(C) existence of free protons (D) existence of body centered cubic lattice

D-2. Which of the following will appears silvery white ?

(A) Li (B) K (C) Na (D) All

D-3. Which of the following s-block metal does not react with water ?

(A) K (B) Na (C) Ca (D) Be

D-4. Which of the following option is correct for given reaction ?

$M + H_2SO_4 \longrightarrow$

(A) It reacts vigrously with acid if M is alkali metal.
(B) It reacts readily with acid if M is alkaline earth metal.
(C) metal sulphate and hydrogen gas will form after reaction.
(D) All are correct.

D-5. Be reacts with excess of caustic soda to form :
(A) $Be(OH)_2$ (B) BeO (C) $Na_2[Be(OH)_4]$ (D) $Be(OH)_2.BeCO_3$

Section (E) : Oxides, Peroxides, Super Oxides, Hydroxides

E-1. What is [X] in the following reaction ?

$MgCl_2.6H_2O \xrightarrow{\Delta} [X] + HCl + H_2O$

(A) MgO (B) Mg (C) $Mg(OH)_2$ (D) Mg(OH)Cl.

E-2. When magnesium burns in air, compounds of magnesium formed are magnesium oxide and :
(A) Mg_3N_2 (B) $MgCO_3$ (C) $Mg(NO_3)_2$ (D) $Mg(NO_2)_2$

E-3. Which product will be formed after the reaction

KOH (Dry powder) + O_3(Ozonised oxygen) $\xrightarrow{-10°C \text{ to } -15°C}$ Product (Orange solid)

(A) KO_2 (B) KO_3 (C) K_2O_3 (D) K_2O

E-4. Peroxide ion is present in :
(A) KO_2 (B) CaO (C) Li_2O (D) BaO_2

E-5. The compound that gives hydrogen peroxide on treatment with a dilute cold acid is :
(A) PbO_2 (B) Na_2O_2 (C) MnO_2 (D) SnO_2

E-6. Products of following reaction :

$NaOH + ZnO \longrightarrow$

(A) $Na_2O, Zn(OH)_2$ (B) Na_2ZnO_2, H_2O (C) $Na_2O_2 , Zn(OH)_2$ (D) None of these

E-7. The principal products obtained on heating iodine with concentrated caustic soda solution is :
(A) NaIO + NaI (B) NaIO + $NaIO_3$ (C) $NaIO_3$ + NaI (D) $NaIO_4$ + NaI

E-8. Products of the following reaction are :

$NaOH + S \longrightarrow$

(A) $Na_2S, Na_2S_2O_3 , H_2O$ (B) Na_2SO_4, H_2O (C) Na_2O_2, Na_2SO_4 (D) H_2S , Na_2SO_4

Section (F) : Carbonates, Bicarbonates

F-1. Which of the following can not decompose on heating to give CO_2 in a dry test tube ?
(A) Li_2CO_3 (B) Na_2CO_3 (C) $KHCO_3$ (D) $BeCO_3$

F-2. $2(Na_2CO_3. NaHCO_3 . 2H_2O) \xrightarrow{heat}$ Products.
Which of the following is not product of this reaction?
(A) Na_2CO_3 (B) CO_2 (C) H_2O (D) Na_2O

F-3. 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 $NaHCO_3$

F-4. $CaCO_3 + HNO_3 \longrightarrow$ Products :
(A) $Ca(NO_3)_2, H_2O, CO_2$ (B) $Ca(NO_3)_2, H_2CO_3$
(C) Ca_3N_2, CO_2, H_2O (D) None of these

F-5. $CO_2 + NaOH \longrightarrow Na_2CO_3 + H_2O$
This reaction shows following nature of CO_2
(A) Acidic (B) basic (C) Neutral (D) Amphoteric

F-6. When SO_2 gas in excess is passed into an aqueous solution of Na_2CO_3, product formed is :
(A) $NaHSO_4$ (B) Na_2SO_4 (C) $NaHSO_3$ (D) All

Section (G) : Chlorides, Sulphates

G-1. Which of the following sulphate have highest thermal stability
(A) Li_2SO_4 (B) Na_2SO_4 (C) K_2SO_4 (D) $CsSO_4$

G.2_ What product will be obtained when magnesite ($MgCO_3$) dissolve in hot dil. H_2SO_4 ?
(A) $MgSO_4$, H_2O, CO_2 (B) MgS, H_2O, CO_2
(C) $MgSO_4$, H_2CO_3 (D) MgS, H_2CO_3

G-3. $CaSO_4$ can be prepared by reaction of any calcium salt with ?
(A) Sulphuric acid (B) Soluble sulphate (C) Both (A) and (B) (D) None of these

G-4. Aqueous solution of NaCl is :
(A) Acidic (B) Basic (C) Neutral (D) None of these

G-5. Aqueous solution of $BeCl_2$ is:
(A) Acidic (B) Basic (C) Neutral (D) None of these

Section (H) : Miscellaneous (Hydrides, Carbides, Nitrates)

H-1. Which of the following is least stable
(A) BeH_2 (B) MgH_2 (C) CaH_2 (D) BaH_2

H-2. $Ca + H_2 \longrightarrow [X] \xrightarrow{+H_2O} [Y] + [Z]$
Total number of atom in one molecule or formula unit of [Y] & [Z] is ?
(A) 7 (B) 3 (C) 4 (D) 5

H-3. $Be_2C + H_2O \longrightarrow Be(OH)_2 + [X]$; "X" is :
(A) C_2H_2 (B) $CH_3–C\equiv CH$ (C) C_2H_6 (D) CH_4

H-4. At high temperature, nitrogen combines with CaC_2 to give :
(A) calcium cyanide (B) calcium cyanamide
(C) Calcium carbonate (D) calcium nitride

H-5. Compounds of alkaline earth metals are less soluble in water than the corresponding alkali metal salts due to :
(A) their high ionisation energy (B) their low electronegativity
(C) their low hydration energy (D) their high lattice energy

H-6. Bleaching powder turns Red litmus to blue and finally white, it is due to :
(A) $OH^–$ (B) HCl (C) $OCl^–$ (D) $Cl^–$

PART - III : MATCH THE COLUMN

1. Match the reactions listed in column-I with the characteristic(s) of the products listed in column-II.

Column – I	Column – II
(A) $Na_2O_2 \xrightarrow{\Delta}$	(p) One of the products is diamagnetic.
(B) $KO_2 \xrightarrow[\text{(ii) C }\Delta]{\text{(i) S }\Delta}$	(q) One of the products acts as reducing agent.
(C) $NaNO_3 \xrightarrow{800^oC}$	(r) One of the products acts as oxidising agent.
(D) $Ba(NO_3)_2 \xrightarrow[500^\circ C]{\Delta}$	(s) One of the products is a basic oxide.

2. Match the compounds listed in column-I with the characteristic(s) listed in column-II.

Column-I	**Column-II**
(A) BeO (s)	(p) Amphoteric in nature
(B) $NaHCO_3$ (crystalline)	(q) Imparts characteristic colour to Bunsen flame.
(C) $BeCl_2$(s)	(r) Produce H_2O_2 and O_2 on reaction with water.
(D) CsO_2(s)	(s) Show hydrogen bonding
	(t) Has a chain structure

Exercise-2

✍ **Marked Questions may have for Revision Questions.**

PART - I : ONLY ONE OPTION CORRECT TYPE

1. The element having electronic configuration $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^1$ will form :
(A) Acidic oxide (B) Basic oxide (C) Amphoteric oxide (D) Netural oxide

2.✍ Beryllium has less negative value of reduction potentials compared to other alkaline earth metals due to:
(A) the smaller hydration energy of the Be^{2+} .
(B) the large value of the atomization enthalpy of the Be metal.
(C) the large value of ionisation energy of the Be metal.
(D) (B) and (C) both.

3.✍ The incorrect statement is :
(A) Be^{2+} cation has largest hydration enthalpy among the alkaline earth metals.
(B) The second ionisation enthalpies of alkalilne earth metals are smaller than those of the corresponding alkali metals.
(C) Li is the strongest reducing agent among all the elements.
(D) Both LiCl and $MgCl_2$ are most covalent in their groups.

4. Select the correct statement with respect to alkali metals.
(A) Melting point decrease with increasing atomic number.
(B) Potassium is lighter than sodium.
(C) Salts of Li to Cs impart characteristic colour to an oxidising flame (of Bunsen burner).
(D) All of these.

5. On dissolving moderate amount of sodium metal in liquid NH_3 at low temperature, which one of the folloiwng does not occur ?
(A) Blue coloured solution is obtained
(B) Na^+ ions are formed in the solution
(C) Liquid NH_3 becomes good conductor of electricity
(D) Liquid NH_3 remains diamagnetic.

6. The incorrect statement is :
(A) KOH can be used as an absorbent of carbondioxide.
(B) Liquid Na metal is used as a coolant in fast breeder nuclear reactors.
(C) All alkali metal gives flame test.
(D) Lithium is the weakest reducing agent among alkali metals.

7. Consider the following statements ;
S_1 : Alkali metals are never found in free state in nature.
S_2 : The melting and boiling points of alkali metals are high.
S_3 : The ceasium and potassium both are used as electrodes in photoelectric cells.
S_4 : Alkali metals are normally kept in kerosene oil.
and arrange in the order of true/false.
(A) T T F F (B) T F T T (C) F F F T (D) T T F T

8. The incorrect statement is :
(A) The alkaline earth metals readily reacts with acids liberating dihydrogen.
(B) Lithium is the only alkali metal to form a nitride directly by heating with N_2 gas.
(C) Calcium cannot be prepared by electrolysis of its aqueous salt solution.
(D) The mobilities of the alkali metal ions in aqueous solution are $Li^+ > Na^+ > K^+ > Rb^+ > Cs^+$.

9. Which of the following reacts with H_2O at room temperature?
(A) Be (B) Li (C) Mg (D) All of these

10. Which of the following fails to react significantly with air at room temperature?
(A) Be (B) Li (C) Ba (D) All of these

11. The pair of amphoteric hydroxides is :
(A) $Be(OH)_2$, $Al(OH)_3$ (B) $Al(OH)_3$, LiOH (C) $B(OH)_3$, $Be(OH)_2$ (D) $Be(OH)_2$, $Mg(OH)_2$

12. $Na_2[Be(OH)_4]$ is formed when ;
(A) BeO reacts with NaOH solution. (B) $Be(OH)_2$ reacts with NaOH solution.
(C) both (A) and (B) are correct. (D) none of the above is correct.

13. Drying agent which react with CO_2 and removes water vapours from ammonia is :
(A) CaO (B) $CaCl_2$ (C) $CaCO_3$ (D) $Ca(NO_3)_2$

14. Brine solution on electrolysis will not give :
(A) NaOH (B) Cl_2 (C) H_2 (D) CO_2

15. Chemical (A) is used for water softening to remove temporary hardness. A reacts with $Na_2\ CO_3$ to generate caustic soda. When CO_2 is bubled through (A), it turns cloudy (i.e. milky). What is the chemical formula of (A) ?
(A) $CaCO_3$ (B) CaO (C) $Ca(OH)_2$ (D) $Ca(HCO_3)_2$

16. (X) reacts with sulphur dioxide in aqueous medium to give $NaHSO_3$, (X) is :
(A) Na_2CO_3 (B) $NaNO_3$ (C) $Na_2S_2O_3$ (D) $NaHSO_4$

17. In Solvay process of manufacture of Na_2CO_3 , the by products obtained from recovery tower are :
(A) NH_4Cl, CaO, CO_2 (B) CaO, Na_2CO_3, $CaCl_2$
(C) $CaCl_2$, CO_2 , NH_3 (D) Na_2CO_3 , $CaCl_2$, CO_2

18. A colourless solid (X) on heating evolved CO_2 and also gave a white residue, soluble in water. Residue also gave CO_2 when treated with dilute acid. (X) is :
(A) K_2CO_3 (B) $CaCO_3$ (C) $KHCO_3$ (D) Na_2CO_3

19. Crude common salt becomes damp on keeping in air because :
(A) It is hygroscopic in nature.
(B) It contains $MgCl_2$ and $CaCl_2$ as impurities which are deliquescent in nature.
(C) (A) and (B) both.
(D) none.

20. $CaCl_2 + H_2SO_4 \xrightarrow[-HCl]{(p)} CaSO_4.2H_2O \xrightarrow{(q)} (r) \xrightarrow{> 393\ K} (s)$

Which of the following option describes, the products, reactants and the reaction conditions.

Option	(p)	(q)	(r)	(s)
(A)	Crystallisation	Heat at 393 K	2 $CaSO_4.H_2O$	$CaSO_4$
(B)	Crystallisation	Heat at 393 K at high pressure	2 $CaSO_4.H_2O$	$CaSO_4$
(C)	Higher temperature	Cool	$CaSO_4.H_2O$	$CaSO_4$
(D)	Higher pressure	Heat at 393 K	$CaSO_4$	$CaSO_3$

21. Setting of plaster of paris involves :
(A) the oxidation with atmoshperic oxygen.
(B) the removal of water to form anhydrous calcium sulphate.
(C) the hydration to form the orthorhombic form of gypsum.
(D) the reaction with atmospheric carbondioxide gas.

22. Calcium cyanamide on reaction with steam under pressure gives ammonia and ------------- .
(A) calcium carbonate (B) calcium hydroxide (C) calcium oxide (D) calcium bicarbonate

PART - II : SINGLE AND DOUBLE VALUE INTEGER TYPE

1. How many of the following are correctly matched ?

Element	Colour in flame test
K	Violet/Lilac
Na	Yellow
Be	Crimson red
Ca	Brick red
Sr	Apple green
Mg	No colour
Rb	Red violet
Cs	Blue
Li	Crimson red

2. How many of the following form polymeric chains?
$BeCl_2$, $AlCl_3$, $NaHCO_3$, Li_2CO_3, BeH_2, Na_2CO_3

3. For alkali metal M :
$M_2O + H_2O \rightarrow x$
$M_2O_2 + H_2O \rightarrow x + y$
$MO_3 + H_2O \rightarrow x + y + z$
Sum of the number of atoms present in one molecule each of x, y, z.

4. $NaOH + PbO \xrightarrow{\Delta} x + H_2O$
$NaOH + SnO_2 \xrightarrow{\Delta} y + H_2O$
$NaOH + H_2O + Al \xrightarrow{\Delta} z + H_2$
Sum of the number of atoms present in one molecule each of x, y, z is........... (Assume no complex formation)

5. How many of the following will turn moist red litmus blue and finally white?
Li_2O, KO_3, RbO_2, Cs_2O_2, BeO, MgO, BaO_2, SrO

6. The by product of solvay process reacts with Na_2CO_3 to form a compound x, which on heating decomposes to give y. y is absorbed by KO_2. The number of atoms per molecule of y is ....

7. How many of the following statement is/are correct?
(a) Solvay process is used for manufacturing sodium carbonate.
(b) $CaCl_2$ is obtained as by product in Solvay process.
(c) NH_3 can be recovered in above process.
(d) $MgSO_4.7H_2O$ is epsom salt.
(e) On hydrolysis of Na_2CO_3, we get an acidic solution due to the formation of H_2CO_3.
(f) K_2CO_3 can also be prepared by Solvay process.
(g) $CaCO_3$ can be obtained by passing excess of CO_2 through lime water.

8. $A + B + H_2O \longrightarrow (NH_4)HCO_3$
$NH_4HCO_3 + NaCl \longrightarrow C + NH_4Cl$
$NH_4Cl + D \longrightarrow 2NH_3 + 2H_2O + CaCl_2$
Sum of the atoms present in one molecule each of A, B, C and D.

9. Molecular formula of Glauber's salt is $Na_2SO_4.xH_2O$. The value of x is_____.

10. When gypsum is heated at 393 K, the compund formed is $CaSO_4.xH_2O$. Value of 6x is.........

PART - III : ONE OR MORE THAN ONE OPTIONS CORRECT TYPE

1. Which is/are not correct configuration of s–block elements :
(A) [Ar] $3d^{10}$ $4s^2$ (B) [Ar] $3d^{10}$ $4s^1$ (C) [Ar]) $4s^2$ (D) [Ar] $4s^1$

2. The set representing the correct order of first ionisation potential is :
(A) K < Na < Li (B) Be > Mg > Ca (C) B > C > N (D) Ge > Si > C

3. The hydration energy of Mg^{2+} ion is higher than that of :
(A) Al^{3+} (B) Ca^{2+} (C) Na^+ (D) None of these

4. Going down in II A group, following properties decrease :
(A) solubility of sulphates in H_2O (B) hydration energy
(C) thermal stability of carbonates (D) ionic radius in water.

5. Exceptionally small size of Lithium results in :
(A) Anomalous behaviour of Li^+. (B) Its high polarising power.
(C) It has high degree of hydration. (D) Exceptionally low ionisation enthalpy.

6. Which of the following statement is incorrect ?
(A) The atomic radius of Na is greater than that of Mg.
(B) Metallic bond in Mg is stronger than the metallic bond in Na.
(C) Melting and boiling points of K are greater than those of Na.
(D) Mg and Ca both impart characteristic colour to the flame.

7. Which of the following statement(s) is/are true ?
(A) All alkali metals are soft and can be cut with knife.
(B) Alkali metals do not occur in free state in nature.
(C) Alkali metals are highly electropositive elements.
(D) Alkali metal hydrides are covalent and low melting solids.

8. Which is/are true statement(s)?
(A) The heats of hydration of the dipositive alkaline earth metal ions decreases with an increase in their ionic size.
(B) Hydration of alkali metal ion is less than that of II A ion of the same period.
(C) Alkaline earth metal ions, because of their much larger charge to radius ratio, exert a much stronger electrostatic attraction on the oxygen of water molecule surrounding them.
(D) None.

9. Which of the following statement(s) is/are correct?
(A) Milk of lime is a suspension of $Ca(OH)_2$ in water.
(B) Lime water is a clear solution of $Ca(OH)_2$ in water.
(C) Baryta water is a clear solution of $Ba(OH)_2$.
(D) Nitrolim is the mixture of $CaCN_2$ and carbon.

10. Select correct statement(s) :
(A) Stability of peroxides and superoxides of alkali metals increases with increase in size of the cation.
(B) Increase in stability in (A) is due to stabilisation of large anions by larger cations through lattice energy effects.
(C) The low solubility of LiF is due to its high lattice energy whereas low solubility of CsI is due to smaller hydration energy .
(D) NaOH is not deliquescent .

11. Select correct statement(s) :
(A) Li_2CO_3 is only sparingly soluble in water and no $LiHCO_3$ has been isolated.
(B) K_2CO_3 cannot be made by a method similar to the ammonia–soda (Solvay) process.
(C) Li_2CO_3 and $MgCO_3$ both are thermally stable.
(D) $KCl.MgCl_2.6H_2O$ is a mineral called carnallite.

12. Sodium bicarbonate can react with :
(A) Na_2CO_3 (B) NaOH (C) NaH (D) HCl

13. Aqueous solution of sodium carbonate can react with :
(A) $MgCl_2$ (B) $Ca(HCO_3)_2$ (C) H_2SO_4 (D) CO_2

14. Which of the following compounds are readily soluble in water?
(A) $MgSO_4$ (B) $SrSO_4$ (C) $BeSO_4$ (D) $BaSO_4$

15. Heating which of the following with C produces a metal sulphide?
(A) Na_2SO_4 (B) $MgSO_4$ (C) $BaSO_4$ (D) Li_2SO_4

16.✍ Which of the following are correctly matched?
(A) Basic strength $Cs_2O < Rb_2O < K_2O < Na_2O < Li_2O$
(B) Stability of peroxides $Na_2O_2 < K_2O_2 < Rb_2O_2 < Cs_2O_2$
(C) Stability of bicarbonates $LiHCO_3 < NaHCO_3 < KHCO_3 < RbHCO_3 < CsHCO_3$
(D) Thermal stability of hydrides CsH < RbH < KH < NaH < LiH

17._ Electrolysis of aqueous NaCl may produce with mercuty cathode :
(A) Na–Hg (B) Cl_2 (C) NaOH (D) H_2

18.✍ A substance (P) releases a gas (Q) on reaction with H_2O. (Q) decolourises Br_2 water. (P) may be :
(A) BeC_2 (B) Be_2C (C) Al_4C_3 (D) Mg_2C_3

19. Nitrate can be converted into metal oxide on heating not above 500ºC in case of :
(A) Li (B) Na (C) Mg (D) None of these.

20.✍ A substance (P), when heated in a dry test tube, liberated a colourless odourless gas that rekindled a glowing splinter. It may be :
(A) $KClO_3$ (B) $NaNO_3$ (C) K_2SO_3 (D) $CaCO_3$

PART - IV : COMPREHENSION

Read the following passage carefully and answer the questions.

Comprehension # 1

All alkali metals dissolve in anhydrous liquid ammonia to give blue colour solution. It is the ammoniated electron which is responsible for the blue colour of the solution, and the electrical conductivity is mainly due to ammoniated electron, $[e(NH_3)_y]^-$. Dilute solutions are paramagnetic due to free ammoniated electrons ; this paramagnetism decreases at higher concentration. Above 3M concentration, the solutions are diamagnetic and no longer blue but are bronze/copper-bronze coloured with a metallic luster.

1. Which of the following changes will be observed in concentrated solution of alkali metal in liquid ammonia ?
(A) Deep blue colour of the solution due to ammoniated electron is retained.
(B) Solvated electrons associate to form electrons-pairs and paramagnetic character decreases.
(C) Reducing character is increased.
(D) Two of the above.

2. Which of the following statement about solution of alkali metals in liquid ammonia is correct ?
(A) The dilute solutions are bad conductor of electricity.
(B) Both the dilute solutions as well as concentrated solution are equally paramagnetic in nature.
(C) Charge transfer is responsible for the blue colour of the solution.
(D) None of these.

3. Ammoniated solutions of alkali metals are reducing agents due to the :
(A) solvated cation. (B) solvated unpaired electron.
(C) the liberation of hydrogen gas (D) (A) and (B) both

Comprehension # 2

Answer Q.4, Q.5 and Q.6 by appropriately matching the information given in the three columns of the following table.

In Column–1 some compounds are given which are treated with the Column–2 compounds or are heated then in column–3 corresponding observations are given.					
Column-1		**Column-2**		**Column-3**	
(I)	Any binary compound of potassium & oxygen	(i)	H_2O	(P)	Liberation of O_2 is possible
(II)	Any alkaline earth metal carbide	(ii)	HCl	(Q)	The resulting solution is alkaline
(III)	Any alkaline earth metal carbonate	(iii)	NaOH	(R)	A gaseous hydrocarbon is liberated
(IV)	A gaseous oxide of non metal in +4 state	(iv)	heat	(S)	A gaseous acidic oxide or acidic solution is formed

4._ Select the incorrect option :
(A) (I) (i) (P) (B) (II) (i) (R) (C) (III) (iv) (S) (D) (IV) (iii) (P)

5._ Select the correct option :
(A) (I) (ii) (R) (B) (I) (i) (Q) (C) (IV) (iii) (S) (D) (II) (i) (S)

6._ Select the correct option :
(A) (IV) (i) (S) (B) (III) (iv) (R) (C) (III) (iii) (S) (D) (III) (ii) (P)

Exercise-3

PART - I : JEE (ADVANCED) / IIT-JEE PROBLEMS (PREVIOUS YEARS)

*** Marked Questions may have more than one correct option.**

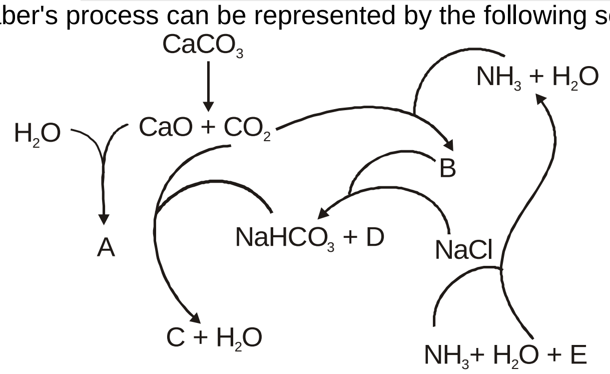
1. Property of the alkaline earth metals that increases with their atomic number is : **[JEE-1997(Cancelled), 2/200]**
(A) ionisation energy (B) solubility of their hydroxides
(C) solubility of their sulphates (D) electronegativity

2.* Highly pure dilute solution of sodium in liquid ammonia : **[JEE-1998, 1/200]**
(A) shows blue colour. (B) exhibits electrical conductivity.
(C) produces sodium amide. (D) produces hydrogen gas.

3.* Sodium nitrate decomposes above 800°C to give : **[JEE-1998, 1/200]**
(A) N_2 (B) O_2 (C) NO_2 (D) Na_2O

4. Beryllium chloride shows acidic nature in water or why $BeCl_2$ is easily hydrolysed ?**[JEE-1999, 2/200]**

5. The Haber's process can be represented by the following scheme :



Identify A, B, C, D and E. **[JEE-1999, 5/200]**

6. A white solid is either Na_2O or Na_2O_2. A piece of red litmus paper turns white when it is dipped into a freshly made aqueous solution of the white solid. **[JEE-1999, 4/200]**
(i) Identify the substances and explain with balanced equation.
(ii) Explain what would happen to the red litmus if the white solid were the other compound.

7. The set representing the correct order of first ionization potential is: **[JEE-2001, 1/35]**
(A) K > Na > Li (B) Be > Mg > Ca (C) B > C > N (D) Ge > Si > C

8. Identify the following :
$$Na_2CO_3 \xrightarrow{SO_2} A \xrightarrow{Na_2CO_3} B \xrightarrow[\Delta]{\text{elemental S}} C \xrightarrow{I_2} D$$
Also mention the oxidation state of S in all the compounds. **[JEE-2003, 4/60]**

9. **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). **[JEE-2007, 3/162]**
(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 a correct explanation for Statement-1.
(C) Statement-1 is True, Statement-2 is False.
(D) Statement-1 is False, Statement-2 is True.

10.* The compound(s) formed upon combustion of sodium metal in excess air is(are) : **[JEE-2009, 4/160]**
(A) Na_2O_2 (B) Na_2O (C) NaO_2 (D) NaOH

PART - II : JEE (MAIN) / AIEEE PROBLEMS (PREVIOUS YEARS)

1. KO_2 (potassium super oxide) is used in oxygen cylinders in space and submarines because it :
(1) Absorbs CO_2 and increases O_2 contents (2) Eliminates moisture
(3) Absorbs CO_2 (4) Produces ozone **[AIEEE-2002]**

2. A metal M readily forms water soluble sulphate MSO_4 , water insoluble hydroxide $M(OH)_2$ and oxide MO which becomes inert on heating. The hydroxide is soluble in NaOH. The M is : **[AIEEE-2002]**
(1) Be (2) Mg (3) Ca (4) Sr

3. In curing cement plasters, water is sprinkled from-time to time. This helps in : **[AIEEE-2003]**
(1) developing interlocking needle like crystals of hydrate silicates
(2) hydrated sand gravel mixed with cement
(3) converting sand into silicic acid
(4) keeping it cool.

4. The substance not likely to contain $CaCO_3$ is : **[AIEEE-2003]**
(1) calcined gypsum (2) sea shells (3) dolomite (4) a marble statue

5. The solubilities of carbonates decrease down the magnesium group due to a decrease in : **[AIEEE-2003]**
(1) hydration energies of cations (2) inter ionic interaction
(3) entropy of solution formation (4) lattice energies of solids.

6. Several blocks of magnesium are fixed to the bottom of a ship to : **[AIEEE-2003]**
(1) make the ship lighter (2) prevent action of water and salt
(3) prevent puncturing by under-sea rocks (4) keep away the sharks.

7. One mole of magnesium nitride on the reaction with an excess of water gives : **[AIEEE-2004]**
(1) one mole of ammonia (2) one mole of nitric acid
(3) two moles of ammonia (4) two moles of nitric acid.

8. Beryllium and aluminium exhibit many properties which are similar. But, the two elements differ in **[AIEEE-2004]**
(1) exhibiting maximum covalency in compounds (2) forming polymeric hydrides
(3) forming covalent halides (4) exhibiting amphoteric nature in their oxides.

9. Following statements regarding the periodic trends of chemical reactivity of the alkali metals and the halogens are given. Which of these statements gives the correct picture ? **[AIEEE-2006]**
(1) The reactivity decreases in the alkali metals but increases in the halogens with increase in atomic number down the group.
(2) In both the alkali metals and the halogens the chemical reactivity decreases with increase in atomic number down the group.
(3) Chemical reactivity increases with increase in atomic number down the group in both the alkali metals and halogens.
(4) In alkali metals the reactivity increases but in the halogens it decreases with increase in atomic number down the group.

10. The ionic mobility of alkali metal ions in aqueous solution is maximum for : **[AIEEE-2006]**
(1) K^+ (2) Rb^+ (3) Li^+ (4) Na^+

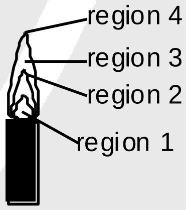
11. Which one of the following orders presents the correct sequence of the increasing basic nature of the given oxides ? **[AIEEE-2011, 4/120]**
(1) $Al_2O_3 < MgO < Na_2O < K_2O$ (2) $MgO < K_2O < Al_2O_3 < Na_2O$
(3) $Na_2O < K_2O < MgO < Al_2O_3$ (4) $K_2O < Na_2O < Al_2O_3 < MgO$

12. The products obtained on heating $LiNO_3$ will be : **[AIEEE-2011, 4/120]**
(1) $Li_2O + NO_2 + O_2$ (2) $Li_3N + O_2$ (3) $Li_2O + NO + O_2$ (4) $LiNO_3 + O_2$

13. Which of the following on thermal decomposition yields a basic as well as acidic oxide ? **[AIEEE-2011, 4/120]**
(1) $NaNO_3$ (2) $KClO_3$ (3) $CaCO_3$ (4) NH_4NO_3

14. Which one of the following alkaline earth metal sulphates has its hydration enthalpy greater than its lattice enthalpy ? **[JEE(Main)-2015, 4/120]**
(1) $CaSO_4$ (2) $BeSO_4$ (3) $BaSO_4$ (4) $SrSO_4$

15. The hottest region of Bunsen flame shown in the figure below is: **[JEE(Main)-2016, 4/120]**



(1) region 2 (2) region 3 (3) region 4 (4) region 1

16. The main oxides formed on combustion of Li, Na and K in excess of air are, respectively: **[JEE(Main)-2016, 4/120]**
(1) LiO_2, Na_2O_2 and K_2O (2) Li_2O_2, Na_2O_2 and KO_2
(3) Li_2O, Na_2O_2 and KO_2 (4) Li_2O, Na_2O and KO_2

17. Both lithium and magnesium display several similar properties due to the diagonal relationship; however, the one which is incorrect, is : **[JEE(Main)-2017, 4/120]**
(1) both form soluble bicarbonates
(2) both form nitrides
(3) nitrates of both Li and Mg yield NO_2 and O_2 on heating
(4) both form basic carbonates

Answers

EXERCISE - 1

PART – I

A-1. After removal of I[st] electron alkali metal occupies inert gas configuration. Now removal of II[nd] electron from inert gas configuration requires very high energy, therefore, they form unipositive ions. As IE_1 of these metals are low, the excitation of electrons can be done by providing less energy. This much of energy can be given by Bunsen flame. When they drop back to the ground state, there is emission of radiation in the visible region.

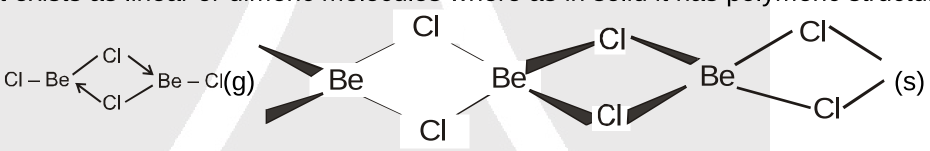
B-1. **(a)** The ionization enthalpy ($\Delta_i H$) of potassium (419 kJ mol^{-1}) is less than that of sodium (496 kJ mol^{-1}) or more precisely the standard electrode potential (E^o) of potassium (– 2.925 V) is more negative than that of sodium (– 2.714 V) and hence potassium is more reactive than sodium.
(b) IE_1 of Mg ($3s^2$) > Na ($3s^1$)
as Mg has fully filled electronic configuration while Na has one unpaired electron.
IE_2 of Mg ($3s^1$) > Na ($2p^6$)
as Mg^+ ($3s^1$) has one unpaired electron and Na^+ has inert gas configuration.

B-2. Smaller the size of the ion, more highly it is hydrated and hence greater is the mass of the hydrated ion and hence lower is its ionic mobility. Since the extent of hydration decreases in the order :
$Li^+ > Na^+ > K^+ > Rb^+ > Cs^+$
therefore, ionic mobility increases in the order :
$Li^+ < Na^+ < K^+ < Rb^+ < Cs^+$

C-1. The superoxide O_2^- is paramagnetic because of one unpaired electron in π^*2p molecular orbital.

C-2. In vapour state it exists as linear or dimeric molecules where as in solid it has polymeric structure,

Cl – Be – Cl(g)



C-3. In [CO_3^{2-}] all C–O bonds are equal due to resonance with B.O = $\frac{3}{2}$, so their bond length will also be equal.

C-4. There will be more polarisation of big anion due to Fajan's factors, so covalent character will be more in I^- due to large size and Ionic character will be less.
$MgCl_2 > MgBr_2 > MgI_2$

C-5. Due to small size Li^+, it has high polarising power while from Na^+ to Cs^+ have bigger size. So they have low polarising power. Li^+ is more similar to Mg^{2+} in its properties, which destabilizes a polyatomic anion due to its high polarising power.

C-6. $BeSO_4 < MgSO_4 < CaSO_4 < SrSO_4$

C-7. NaOH < KOH < RbOH < CsOH

C-8. Lithium is expected to be least reducing agent due to it's very high I.E. However, lithium has the highest hydration enthalpy due to small size which accounts for its high negative $E^{\ominus}$ and its high reducing power.

D-1. Due to large atomic size & only one valence electron per atom, alkali metals have weak metallic bonds as interparticle forces.

D-2.

Group-I Elements	+ O_2 (Major product)	+ N_2 (product)	Group-II Elements	+ O_2 (Major product)	+ N_2 (product) (Only on strong heating)
Li	Li_2O (Oxide)	Li_3N	Be	BeO	Be_3N_2
Na	Na_2O_2 (Peroxide)	It does not react	Mg	MgO	Mg_3N_2
K	KO_2 (superoxide)	It does not react	Ca	CaO	Ca_3N_2
Rb	RbO_2 (superoxide)	It does not react	Sr	SrO_2	Sr_3N_2
Cs	CsO_2 (superoxide)	It does not react	Ba	BaO_2	Ba_3N_2

D-3. (a) $Na + H_2O \longrightarrow NaOH + \frac{1}{2}H_2\uparrow$ (b) $Ca + 2H_2O \longrightarrow Ca(OH)_2 + H_2\uparrow$

D-4. (i) $M + H_2SO_4 \longrightarrow M_2SO_4 + H_2\uparrow$

(ii) $M + 2HCl \longrightarrow MCl_2 + H_2\uparrow$

D-5. On dissolving Metal in Liquid NH_3

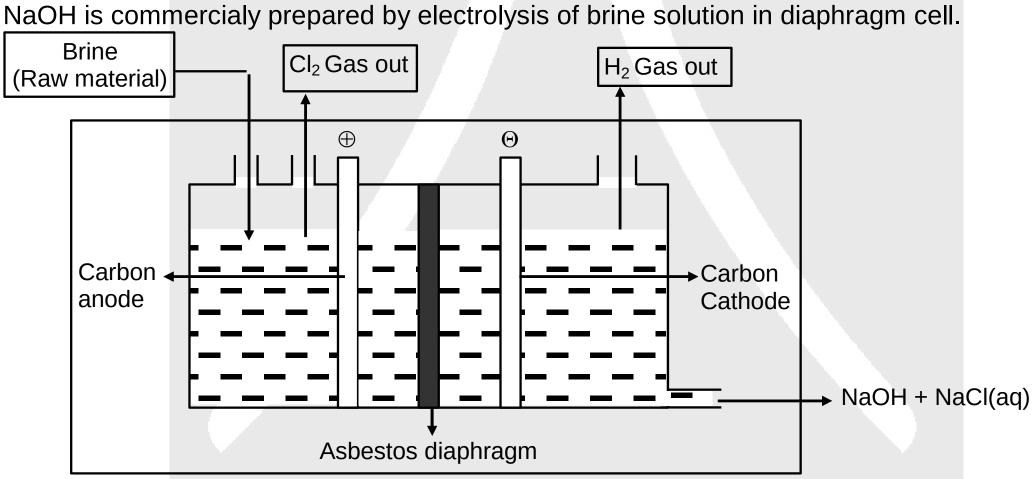
$M(s) + 2NH_3(\ell) \longrightarrow M^+(NH_3) + e^-(NH_3)$

$M^+ + x\,(NH_3) \longrightarrow [M\,(NH_3)_x]^+$ $\longrightarrow$ Ammoniated cation

$e^- + y\,(NH_3) \longrightarrow [e(NH_3)_y]^-$ $\longrightarrow$ Ammoniated electron

E-1. Small cation have high polarizing power therefore it stabilizes monoatomic anion.
e.g. Li_2O
Large cation have less polarizing power therefore it can stabilize polyatomic anion.
e.g. Na_2O_2 ; KO_2

E-2. NaOH is commercialy prepared by electrolysis of brine solution in diaphragm cell.



Anode reaction: $2Cl^- \longrightarrow Cl_2 + 2e^-$

Cathode reactions : $2H_2O + 2e^- \longrightarrow H_2 + 2OH^-$

$Na^+ + OH^- \longrightarrow NaOH$

Over all reaction: $2Na^+ + 2Cl^- + 2H_2O \longrightarrow 2NaOH + H_2 + Cl_2$

E-3. (i) Industrial method : It is a two stage reaction in presence of excess of air.

$2Na + O_2 \longrightarrow Na_2O$

$Na_2O + O_2 \longrightarrow Na_2O_2$

(ii) It is prepared by burning potassium in excess of oxygen free from moisture.

$K + O_2 \longrightarrow KO_2$

Hydrolysis

(i) with cold water, $Na_2O_2 + 2H_2O \xrightarrow{0°C} 2NaOH + H_2O_2$

At room temperature, $2Na_2O_2 + 2H_2O \xrightarrow{25°C} 4NaOH + O_2$

(ii) $KO_2 + H_2O \longrightarrow KOH + \frac{1}{2}H_2O_2 + \frac{1}{2}O_2$

E-4. (a) $\underset{\text{base}}{NaOH} + \underset{\text{acid}}{HNO_3} \longrightarrow \underset{\text{salt}}{NaNO_3} + H_2O$

(b) $Li_2O + H_2SO_4 \longrightarrow Li_2SO_4 + H_2O$

(c) $Na_2O_2 + H_2SO_4(\text{dilute}) \xrightarrow{25^oC} 2Na_2SO_4 + 2H_2O + O_2$

(d) $CaO + HCl \longrightarrow CaCl_2 + H_2O$

E-5. $3Ca(OH)_2 + 2H_3PO_4 \longrightarrow Ca_3(PO_4)_2 + 6H_2O$

E-6. $\underset{\text{base}}{NaOH} + \underset{\text{it will react as acid}}{Al_2O_3}$ (amphoteric metal oxide) $\longrightarrow 2NaAlO_2 + H_2O$

E-7. $Cl_2 \xrightarrow{+\text{cold \& dil. NaOH}} \underset{\text{Sod. hypochlorite}}{NaCl + NaOCl + H_2O}$

$Cl_2 \xrightarrow{+\text{hot \& conc. NaOH}} \underset{\text{Sod. chlorate}}{NaCl + NaClO_3 + H_2O}$

E-8. It goes under disproportionation reaction

$\overset{(0)}{P_4}$ (white) + NaOH + $H_2O \longrightarrow \underset{\text{Sod. hypophosphite}}{NaH_2\overset{+1}{P}O_2} + \underset{\text{Phosphine}}{\overset{-3}{P}H_3}$

F-1. $BeCO_3 < MgCO_3 < CaCO_3 < SrCO_3 < BaCO_3$

Stability of carbonates increases with increase in electropositive character and decrease in polarisation power of metal.

F-2. (i) In ammonia absorber

$NH_3 + CO_2 + H_2O \longrightarrow NH_4HCO_3$;

$NH_4HCO_3 + NaCl \xrightarrow{30^\circ C} NaHCO_3 \downarrow + NH_4Cl$

(ii) Calcination

$2\ NaHCO_3 \xrightarrow{150^\circ C} Na_2CO_3 + CO_2 + H_2O$

(iii) In recovery tower :-

$NH_4\ HCO_3 \xrightarrow{\Delta/\text{steam}} NH_3 + CO_2 + H_2O$

$2NH_4\ Cl + Ca(OH)_2 \xrightarrow{\Delta/\text{steam}} 2NH_3 + 2H_2O + CaCl_2$

F-3. $Na_2CO_3 + HCl(\text{dil.}) \longrightarrow NaCl + H_2O + CO_2$

F-4. **(a)** $2NaHCO_3 + H_2SO_4 \longrightarrow 2Na_2SO_4 + 2H_2O + CO_2$

(b) $Na_2CO_3 + Ca(OH)_2 \longrightarrow CaCO_3 \downarrow + 2NaOH$

(c) $NaHCO_3 + NaOH \longrightarrow Na_2CO_3 + H_2O$

(d) $2NaHCO_3 \xrightarrow[\text{Boil}]{\Delta} Na_2CO_3 + H_2O + CO_2 \uparrow$

(e) $NaHCO_3 + CaCl_2 \xrightarrow{\text{room temperature}}$ No reaction.

G-1. $BeSO_4 > MgSO_4 > CaSO_4 > SrSO_4$ Bigger cation is stable with bigger anion where as smaller cation is less stable with bigger anion that why $BeSO_4$ is more water soluble.

G-2. It is produced in large amount as a by product in solvey process.

G-3. $CaSO_4.2H_2O \xrightarrow{120^oC,\ \Delta} CaSO_4.\ \frac{1}{2}H_2O$ (Plaster of Paris) $+ \frac{3}{2}H_2O$

G-4. (i) Be^{2+} & O^{2-} smaller in size & thus higher lattice energy and lattice energy is greater than hydration energy in BeO where as in $BeSO_4$ lattice energy is less due to bigger sulphate ion and is soluble.

Order of solubility : BeO < MgO < CaO < SrO < BaO

(ii) In $BaSO_4$ lattice energy is greater than hydration energy while in BaO lattice energy is smaller than hydration energy.

Order of solubility : $BeSO_4 > MgSO_4 > CaSO_4 > SrSO_4 > BaSO_4$

G-5. $NaOCl + HOH \longrightarrow NaOH + HOCl$

G-6. $CaCl_2 + H_2SO_4$ (conc.) $\xrightarrow{\Delta} CaSO_4 + 2HCl$

H-1. Order is LiH > NaH > KH > RbH > CsH because small Li^+ due to high polarisation power will stablise smaller anion.

H-2. **(a)** $CaC_2 + 2H_2O \longrightarrow Ca(OH)_2 + C_2H_2$

(b) $Mg_2C_3 + 4HOH \longrightarrow 2Mg(OH)_2 + CH_3-C\equiv CH$

H-3. **(i)** $2MNO_3$ (metal nitrate) $\xrightarrow{500^oC,\ \Delta} 2MNO_2$ (Metal nitrite) + O_2 (except Li)

$4Li\ NO_3 \xrightarrow{500^oC,\ \Delta} Li_2O + 4NO_2 + O_2$

(ii) $M(NO_3)_2 \xrightarrow{\Delta} MO + 2NO_2 + \frac{1}{2}\ O_2$

H-4. (a) $Li_3N + 3H_2O \longrightarrow 3LiOH + NH_3\uparrow$ (b) $NaNH_2 + H_2O \longrightarrow NaOH + NH_3\uparrow$

PART – II

A-1.	(A)	**A-2.**	(B)	**B-1.**	(B)	**B-2.**	(A)	**C-1.**	(B)
C-2.	(D)	**C-3.**	(D)	**C-4.**	(C)	**C-5.**	(B)	**C-6.**	(A)
D-1.	(B)	**D-2.**	(D)	**D-3.**	(D)	**D-4.**	(D)	**D-5.**	(C)
E-1.	(A)	**E-2.**	(A)	**E-3.**	(B)	**E-4.**	(D)	**E-5.**	(B)
E-6.	(B)	**E-7.**	(C)	**E-8.**	(A)	**F-1.**	(B)	**F-2.**	(D)
F-3.	(C)	**F-4.**	(A)	**F-5.**	(A)	**F-6.**	(C)	**G-1.**	(D)
G-2.	(A)	**G-3.**	(C)	**G-4.**	(C)	**G-5.**	(A)	**H-1.**	(D)
H-2.	(A)	**H-3.**	(D)	**H-4.**	(B)	**H-5.**	(D)	**H-6.**	(C)

PART – III

1. (A – p,r,s) ; (B – p,q) ; (C – p,q,r,s) ; (D – p,q, r).

2. (A – p) ; (B – p, q, s, t) ; (C – t) ; (D – q, r)

EXERCISE – 2

PART – I

1.	(B)	**2.**	(D)	**3.**	(D)	**4.**	(D)	**5.**	(D)
6.	(D)	**7.**	(B)	**8.**	(D)	**9.**	(B)	**10.**	(A)
11.	(A)	**12.**	(C)	**13.**	(A)	**14.**	(D)	**15.**	(C)
16.	(A)	**17.**	(C)	**18.**	(C)	**19.**	(B)	**20.**	(A)
21.	(C)	**22.**	(A)						

PART – II

1. 7 (All except Be & Sr) **2.** 3 ($BeCl_2$, $NaHCO_3$, BeH_2)

3. 9 (x = 3, y = 4, z = 2) **4.** 15 (x = 5, y = 6, z = 4)

5. 4 (KO_3, RbO_2, Cs_2O_2, BaO_2) **6.** 3 (CO_2) **7.** 4 (1st four)

8. 18 (4, 3, 6, 5) **9.** 10. **10.** 3

PART – III

1.	(AB)	**2.**	(AB)	**3.**	(BC)	**4.**	(ABD)	**5.**	(ABC)
6.	(CD)	**7.**	(ABC)	**8.**	(ABC)	**9.**	(ABCD)	**10.**	(ABC)
11.	(ABD)	**12.**	(BCD)	**13.**	(ABCD)	**14.**	(AC)	**15.**	(AC)
16.	(BCD)	**17.**	(ABCD)	**18.**	(AD)	**19.**	(AC)	**20.**	(AB)

PART – IV

1.	(D)	**2.**	(D)	**3.**	(B)	**4.**	(D)	**5.**	(B)
6.	(A)								

EXERCISE – 3

PART – I

1. (B) **2.*** (AB) **3.*** (ABD)

4. (i) Beryllium chloride is acidic, when dissolved in water because the hydrated ion hydrolysed producing H_3O^+. This happens because the Be–O bond is very strong, and so in the hydrated ion this weakens the O–H bonds, and hence there is tendency to lose portons.

$BeCl_2 + 4H_2O \longrightarrow [Be(H_2O)_4]\,Cl_2$; $[Be(H_2O)_4]^{2+} + H_2O \longrightarrow [Be(H_2O)_3\,(OH)]^+ + H_3O^+$

5. A = $Ca(OH)_2$, B = NH_4HCO_3 , C = Na_2CO_3, D = NH_4Cl, E = $CaCl_2$

6. (i) Na_2O_2 is powerful oxidant and bleaching agent and bleaches red litmus paper to white in aqueous solution according to the following reaction,

$Na_2O_2 + 2H_2O \longrightarrow 2NaOH + H_2O + [O]$

[O] + Litmus $\longrightarrow$ White (bleaching)

(ii) The other compound Na_2O will give NaOH on dissolution in water according to the following reaction.

$Na_2O + H_2O \longrightarrow 2NaOH$.

The red litmus will turn to blue due to stronger alkaline nature of NaOH

7. (B)

8. $Na_2CO_3 + SO_2 \xrightarrow{H_2O} 2NaHSO_3\,(A) + CO_2$

$2NaHSO_3 + Na_2CO_3 \longrightarrow 2Na_2SO_3\,(B) + H_2O + CO_2$

$Na_2SO_3 + S \xrightarrow{\Delta} Na_2S_2O_3\,(C)$

$2Na_2S_2O_3 + I_2 \longrightarrow Na_2S_4O_6\,(D) + 2NaI$

Oxidation states of S + 4 in $NaHSO_3$ [1 + 1 + x + 3(–2) = 0] and +4 in Na_2SO_3 [2 + x + 3(–2) = 0] ;
+ 6 and – 2 (or an average + 2) in $Na_2S_2O_3$ and +5 and 0 (or an average + 5/2) in $Na_2S_4O_6$.

9. (B) **10.*** (AB)

PART – II

1.	(1)	**2.**	(1)	**3.**	(1)	**4.**	(1)	**5.**	(1)
6.	(2)	**7.**	(3)	**8.**	(1)	**9.**	(4)	**10.**	(2)
11.	(1)	**12.**	(1)	**13.**	(3)	**14.**	(2)	**15.**	(1)
16.	(3)	**17.**	(4)						

Additional Problems for Self Practice (APSP)

Marked questions are recommended for Revision.

This Section is not meant for classroom discussion. It is being given to promote self-study and self testing amongst the Resonance students.

PART - I : PRACTICE TEST-1 (IIT-JEE (MAIN Pattern))

Max. Time : 1 Hr. **Max. Marks : 120**

Important Instructions

1. The test is of **1 hour** duration.
2. The Test Booklet consists of **30** questions. The maximum marks are **120.**
3. Each question is allotted **4 (four)** marks for correct response.
4. Candidates will be awarded marks as stated above in Instructions No. 3 for correct response of each question. ¼ **(one fourth)** marks will be deducted for indicating incorrect response of each question. No deduction from the total score will be made if no response is indicated for an item in the answer sheet.
5. There is only one correct response for each question. Filling up more than one response in any question will be treated as wrong response and marks for wrong response will be deducted accordingly as per instructions 4 above.

1. Which of the following has maximum ionisation energy ?
(1) $Ba \rightarrow Ba^+ + e^-$ (2) $Be \rightarrow Be^+ + e^-$ (3) $Ca \rightarrow Ca^{2+} + 2e^-$ (4) $Mg \rightarrow Mg^{2+} + 2e^-$

2. Which of the following increases in magnitude as the atomic number of alkali metals increases?
(1) Electronegativity (2) First ionisation potential
(3) Ionic radius (4) Melting point

3. Alkali metals give colour in Bunsen flame due to :
(1) Low electronegativeity (2) One electron in outer most orbit
(3) Smaller atomic radii (4) Low ionisation energy

4. Which of the following s about solution of alkali metals in liquid ammonia is correct ?
(1) The solutions have strong oxidizing properties.
(2) Both the dilute solution as well as concentrated solution are paramagntic in nature.
(3) Colour of the solution is attributed to charge transfer spectrum.
(4) None of these.

5. Select the incorrect statement :
(1) Solutions of alkali metals in liquid ammonia are a good reducing agents because they contain free or solvated electrons.
(2) The crystalline salts of alkaline earth metals contain more water of crystallisation than the corresponding alkali metal salts.
(3) Atoms of alkaline earth metals have smaller size and more nuclear charge than alkali metal atoms of same period.
(4) All alkali metal halides form hydrates.

6. Consider the following statements ;
S_1 : Among alkali metal halides lithium iodide is the most covalent in nature.
S_2 : Potassium has greater photoelectric work function than sodium.
S_3 : The blue solution of alkali metals in liquid ammonia is stable at room temperature, where ammonia is still a liquid, in the presence of Fe.
S_4 : The melting and boiling points of alkali metal halides always follow the trend : chloride > fluoride > bromide > iodide.
and arrange in the order of true/false.
(1) T F F F (2) T T F F (3) T F T T (4) T T T F

7. Which of the following has the highest reactivity towards water ?
(1) Na (2) Rb (3) Li (4) K

8. Sodium burns in dry air to largely give :
(1) Na_2O (2) Na_2O_2 (3) NaO_2 (4) Na_3N

9. Alkali metals are not characterised by :
(1) good conductor of heat and electricity (2) high oxidation potentials
(3) high melting points (4) solubility in liquid ammonia

10. In view of their ionisation energies, the alkali metals are :
(1) weak oxidising agents (2) strong reducing agents
(3) strong oxidising agents (4) weak reducing agents

11. Which of the following is incorrect statement :
(1) Solubilities of alkaline earth metal fluorides and hydroxides generally increase down the group.
(2) Hydration energies of alkali metal halides decrease down the group with increase in size of cations.
(3) Mg^{2+} ion is bigger than Li^+.
(4) $BeCl_2$ is easily hydrolysed in water.

12. A metal (M) burns with dazzling brilliance in air above 1000ºC to give a white powder. The white powder reacts with water to form a white precipitate (P) and a colourless gas (G) with a characteristic smell. The metal (M) dissolves in conc. NaOH to liberate another gas(H). (H) may also be obtained on heating (G). Then :
(1) M = Mg (2) M = Be (3) P = $Ca(OH)_2$ (4) G = O_3

13. Carbon can be oxidised to CO_2 while heating its powder with :
(1) SO_2 (2) KNO_3 (3) K_2CO_3 (4) FeS_2

14. What happens when sodium metal is heated in excess of dry air containing carbon dioxide gas ?
(1) Na_2O_2 is formed. (2) Na_2O is formed. (3) Na_2CO_3 is formed. (4) Na_3N is formed.

15. Solution of K_2O in water is basic, because it contains a significant concentration of :
(1) O_2^{2-} (2) O_2^- (3) OH^- (4) K^+

16. Which of the following oxides is formed when potassium metal is burnt in excess air ?
(1) KO_3 (2) K_2O (3) K_2O_2 (4) KO_2

17. On commercial scale, sodium hydroxide is prepared by :
(1) Dow's process (2) Solvay process
(3) Castner-Kellner cell (4) Hall-Heroult process

18. Which of the following gives sodium hydroxide along with hydrogen gas on reaction with water ?
(1) Sodium oxide (2) Sodium amalgam (3) Sodium peroxide (4) Sodium carbonate.

19. Which of the following can exist in aqueous solution?
(1) Na_2O (2) Na_2O_2 (3) KO_2 (4) K_2CO_3

20. Which of the following salts are composed of isoelectronic cation and anion
(I) NaCl (II) $BaCl_2$ (III) MgF_2 (IV) CaS
(1) I and II (2) II and III (3) III & IV (4) None of these

21. Which of the following liberates H_2 with cold water ?
(1) H_2O_2 (2) NaH (3) NaOH (4) Mg

22. When ionic nitrides react with water, the products are :
(1) acidic solution and hydrogen gas. (2) acidic solution and ammonia gas.
(3) basic solution and ammonia gas. (4) basic solution and hydrogen gas.

23. Low solubility of CsI in water is due to :
(1) smaller hydration enthalpy of Cs^+. (2) smaller hydration enthalpy of I^-.
(3) lower lattice enthalpy of its two ions. (4) (1) and (2) both.

24. Select the correct statement.
(1) Among the alkali metals, only lithium reacts with nitrogen directly at room temperature to form nitride.
(2) Among the alkali metal carbonates, Li_2CO_3 has the lowest thermal stability.
(3) Among the alkali metal hydroxide, CsOH has the highest solubility in water.
(4) All of these.

25. $NaNO_3$ is not used as gun powder because it is :
(1) hygroscopic (2) very costly (3) amorphous (4) soluble in water

26. A doctor by mistake administers a dilute $Ba(NO_3)_2$ solution to a patient for radiagraphic investigations. Which of the following should be the best to prevent the absorption of soluble Barium and subsequent Barium poisoning.
(1) NaCl (2) Na_2SO_4 (3) Na_2CO_3 (4) NH_4Cl

27. Baking powder used to make cake is a mixture of starch, $NaHCO_3$ and $Ca(H_2PO_4)_2$. The function of $Ca(H_2PO_4)_2$ is :
(1) to slow down the release of CO_2 gas
(2) it has acidic hydrogen and gives CO_2 when moistened with $NaHCO_3$
(3) to act as a filler
(4) None of these

28. Which salt hydrolyses to a minimum extent ?
(1) $Mg(NO_3)_2$ (2) $Be(NO_3)_2$ (3) $Ca(NO_3)_2$ (4) $Ba(NO_3)_2$.

29. Methanides are :
(1) Mg_2C_3, Be_2C, Al_4C_3 and CaC_2 (2) Mg_2C_3, Be_2C and Al_4C_3
(3) Be_2C, Al_4C_3 and CaC_2 (4) Be_2C and Al_4C_3

30. Select correct statement :
(1) Interstitial carbides are formed by metalloids like Si and B.
(2) SiC and B_4C are covalent carbides.
(3) B_4C on hydrolysis gives methane.
(4) VC, WC are ionic carbides.

Practice Test-1 (IIT-JEE (Main Pattern))

OBJECTIVE RESPONSE SHEET (ORS)

Que.	1	2	3	4	5	6	7	8	9	10
Ans.										
Que.	11	12	13	14	15	16	17	18	19	20
Ans.										
Que.	21	22	23	24	25	26	27	28	29	30
Ans.										

PART-II:NATIONAL STANDARD EXAMINATION IN CHEMISTRY (NSEC) STAGE-I

1. Which of the following is used in the photoelectric cells ? **[NSEC-2000]**
(A) cesium (B) sodium (C) lithium (D) francium

2. Bleaching powder is : **[NSEC-2000]**
(A) $CaOCl_2$ (B) CaClO (C) $CaClO_3$ (D) $Ca(OCl)_2$

3. The chemistry of Li is very similar to that of Mg even though they belong to different groups. This is due to the fact that **[NSEC-2000]**
(A) both occur in nature as compounds. (B) both have same electronic configuration
(C) both have nearly the same size (D) both have charge to size ratio nearly the same.

4. Fire extinguisher contains H_2SO_4 and **[NSEC-2000]**
(A) Na_2CO_3 (B) $NaHCO_3$ solution
(C) $NaHCO_3$ & Na_2CO_3 (D) $CaCO_3$

5. Washing soda is manufactured by : **[NSEC-2001]**
(A) Denni's process (B) Hall's process (C) Castener's process (D) Solvay's process

6. For which element crimson colour is obtained in flame test ? **[NSEC-2002]**
(A) sodium (B) barium (C) strontium (D) calcium

7. Alkali metal dissolves in liquid ammonia at –33°C to produce **[NSEC-2002]**
(A) violet colour (B) blue colour
(C) reddish-violet colour (D) green colour.

8. Portland cement is **[NSEC-2005]**
(A) calcium aluminium silicate (B) alumina
(C) gypsum (D) calcium carbonate.

9. Crystals of washing soda lose nine molecules of water when exposed to dry air. This phenomenon is known as **[NSEC-2005]**
(A) dehydration (B) efflorescence (C) deliquescence (D) evaporation.

10. Bleaching powder is made by passing Cl_2 into slaked lime. Its formula is **[NSEC-2005]**
(A) $Ca(OCl)_2$ (B) $CaO(OCl)$ (C) $CaOCl_2$ (D) $CaCl_2 2H_2O$.

11. The metal that shows photoelectric emission at lowest frequency radiation is **[NSEC-2005]**
(A) beryllium (B) lithium (C) sodium (D) magnesium.

12. The lithium ion (Li^+) and hydride ion (H^-) are isoelectronic ions. Which statement about these systems is true ? **[NSEC-2006]**
(A) Chemical properties of these ions are identical since they are isoelectronic.
(B) Li^+ is a stronger reducing agent than H^-
(C) More energy is needed to ionize H^- than Li^+
(D) Radius of H^- is larger than that of Li^+.

13. Which compound has largest lattice energy ? **[NSEC-2006]**
(A) LiBr (B) LiCl (C) LiI (D) LiF.

14. Element having (4, 0, 0, +1/2) as a set of four quantum numbers for its valence electron is- **[NSEC-2007]**
(A) Na (B) Ca (C) K (D) Br

15. The commercial name of calcium hydride is **[NSEC-2012]**
(A) Lime (B) Hydrolyth (C) Slaked lime (D) Calgon

16. The crimson colour imparted to flame is due to a salt of **:** **[NSEC-2012]**
(A) Barium (B) Copper (C) Calcium (D) Strontium

17. The chemical formula of Plaster of Paris is **[NSEC-2013]**
(A) $2CaSO_4.H_2O$ (B) $CaSO_4.2H_2O$ (C) $3CaSO_4.2H_2O$ (D) $CaSO_4.H_2O$

18. The correct statement for crystalline CsI_3 is **[NSEC-2014]**
(A) it contains Cs^+, I^- and molecular I_2 (B) it is a covalent compound
(C) it contains Cs^+ and I_3^- (D) it contains Cs^{3+} and I^-

19. Sodium metal dissolves in liquid ammonia and forms a deep blue solution. The color is due to absorption of light by **[NSEC-2015]**
(A) sodium ions (B) ammoniated electrons
(C) free electrons (D) ammoniated sodium ions

20.* The reaction that is least feasible is **[NSEC-2015]**
(A) $Li_2CO_3 \rightarrow Li_2O + CO_2$ (B) $4Li + O_2 \rightarrow 2\ Li_2O$
(C) $6Li + N_2 \rightarrow 2Li_3N$. (D) $2C_6H_5C{\equiv}CH + 2Li \rightarrow 2C_6H_5C{\equiv}CLi + H_2$

21. A dilute solution of an alkali metal in liquid ammonia is **[NSEC-2018]**
I. blue in colour II. conducts electricity III. paramagnetic IV. an oxidizing agent
(A) I and III (B) II and IV (C) I, II and III (D) I and III

PART - III : PRACTICE TEST-2 (IIT-JEE (ADVANCED Pattern))

Max. Time : 1 Hr. **Max. Marks : 69**

Important Instructions

A. General :
1. The test is of 1 hour duration.
2. The Test Booklet consists of 23 questions. The maximum marks are 69.

B. Question Paper Format
3. Each part consists of five sections.
4. Section-1 contains 7 multiple choice questions. Each question has four choices (A), (B), (C) and (D) out of which ONE is correct.

5. Section-2 contains 6 multiple choice questions. Each question has four choices (A), (B), (C) and (D) out of which ONE OR MORE THAN ONE are correct.
6. Section-3 contains 6 questions. The answer to each of the questions is a single-digit integer, ranging from 0 to 9 (both inclusive).
7. Section-4 contains 1 paragraphs each describing theory, experiment and data etc. 3 questions relate to paragraph. Each question pertaining to a partcular passage should have only one correct answer among the four given choices (A), (B), (C) and (D).
8. Section-5 contains 1 multiple choice questions. Question has two lists (list-1 : P, Q, R and S; List-2 : 1, 2, 3 and 4). The options for the correct match are provided as (A), (B), (C) and (D) out of which ONLY ONE is correct.

C. Marking Scheme

9. For each question in Section 1, 4 and 5 you will be awarded 3 marks if you darken the bubble corresponding to the correct answer and zero mark if no bubble is darkened. In all other cases, minus one (–1) mark will be awarded.
10. For each question in Section 2, you will be awarded 3 marks. If you darken all the bubble(s) corresponding to the correct answer(s) and zero mark. If no bubbles are darkened. No negative marks will be answered for incorrect answer in this section.
11. For each question in Section 3, you will be awarded 3 marks if you darken only the bubble corresponding to the correct answer and zero mark if no bubble is darkened. No negative marks will be awarded for incorrect answer in this section.

SECTION-1 : (Only One option correct Type)

This section contains 7 Single correct questions. Each questions has four choices (A), (B), (C) and (D) out of which Only ONE option is correct.

---

1. Consider the following statements :

S_1 : Beryllium and Magnesium are inert to oxygen and water.

S_2 : Concentrated solutions of alkaline earth metals in ammonia are bronze coloured.

S_3 : Calcium, strontium and barium reacts with cold water forming hydroxides and liberating hydrogen gas.

S_4 : Oxides and hydroxides of alkaline earth metals are more ionic and more basic than that of the alkali metals.

and arrange in the order of true/false.

(A) T T T T (B) T T T F (C) F T T F (D) F T F F

2. Which of the following statement is incorrect ?

(A) The superoxide ion (i.e., O_2^-) is stable only in presence of larger cations such as K, Rb, Cs.

(B) Alkali metals are normally kept in kerosene oil.

(C) All the alkali metal hydrides are ionic solids with high melting points.

(D) The concentrated solution of alkali metals in liquid ammonia are strong paramagnetic in nature.

3. Sodium is heated in excess of air, free from CO_2 at 350^0C to form X. X absorbs CO_2 and form Na_2CO_3 and Y. 'X' and 'Y' are respectively :

(A) Na_2O and O_2 (B) Na_2O_2 and O_2 (C) NaO_2 and O_2 (D) Na_2O_2 and O_3

4. What products are formed during the electrolysis of a concentrated aqueous solution of sodium chloride?

I. $Cl_2(g)$, II . NaOH (aq)., III. $H_2(g)$.

(A) I only (B) I and II only (C) I and III only (D) All of these

5. The following flow diagram represents the manufacturing of sodium carbonate ?

$$2\,NH_3 + H_2O + CO_2 \longrightarrow (NH_4)_2CO_3 \xrightarrow{(a)} NH_4HCO_3 \xrightarrow{(b)} NaHCO_3 + (c)$$

$$NaHCO_3 \xrightarrow{(d)} Na_2CO_3 + CO_2 + H_2O$$

Which of the following option describes the underlined reagents, products and reaction conditions ?

Option	(a)	(b)	(c)	(d)
(A)	Carbon dioxide	NaCl	NH_4Cl	Heat
(B)	Carbon dioxide	NaCl	NH_4Cl	catalyst
(C)	Higher tempt.	NaCl	NH_4Cl	Heat
(D)	Higher pressure	NaCl	NH_4Cl	Catalyst

6. Which of the following statement is incorrect ?
(A) The effective component of bleaching powder is OCl^-.
(B) $CaCO_3$ is obtained when quick lime is heated with coke in an electric furnace.
(C) Anhydrous $CaSO_4$ is dead burnt plaster.
(D) $BaCO_3$ is obtained on fusion of $BaSO_4$ and Na_2CO_3.

7. Consider the following statements,
S_1 : Gypsum contains a lower percentage of calcium than plaster of pairs.
S_2 : Plaster of paris can be re-obtained by hydration of 'dead plaster'.
S_3 : Gypsum loses 3/2 of its water of crystallisation forming plaster of paris at 120ºC.
S_4 : Plaster of paris can be obtained by partial oxidation of gypsum.
and arrange in the order of true/false.
(A) T F T F (B) F F T F (C) T T F F (D) T T T T

Section-2 : (One or More than one options correct Type)
This section contains 6 multipole choice questions. Each questions has four choices (A), (B), (C) and (D) out of which ONE or MORE THAN ONE are correct.

8. Select the correct statement with respect to the deep blue solution of an alkali metal in liquid ammonia.
(A) Its paramagnetism decreases with increasing concentration.
(B) It has lower density than pure solvent (i.e. liquid ammonia).
(C) Its conductivity decreases with increasing concentration to minimum at about 0.05 molar; thereafter it again increases.
(D) Evaporation of ammonia from the solution yields alkali metal.

9. Freshly prepared pure dilute solution of sodium in liquid ammonia :
(A) shows copper - bronze colour.
(B) occupy larger volume than that from the sum of the volumes of Na and $NH_3(\ell)$.
(C) reduces the GeH_4 to GeH_3^-.
(D) produces sodium amide and hydrogen gas with rusty iron wire.

10. Which of the following disproportionate(s) on heating with sodium hydroxide ?
(A) P_4 (white) (B) S_8 (C) Cl_2 (D) B

11. Which of the following statement(s) is/are correct ?
(A) Pure sodium oxide is obtained by heating the mixture of sodium azide and sodium nitrite.
(B) Glauber's salt effloresces in moist air.
(C) Potassium superoxide on heating with sulphur in an evacuated and sealed tube yields potassium thiosulphate.
(D) Gypsum dissovle in ammonium sulphate solution.

12. Select correct statement(s) :
(A) $CaCO_3$ is more soluble in a solution of CO_2 than in H_2O.
(B) Na_2CO_3 is converted to Na_2O and CO_2 on heating.
(C) Li_2CO_3 is thermally unstable.
(D) Presence of $CaCl_2$ or $CaSO_4$ in water causes temporary hardness.

13. The pair (s) of compounds which can exist together in aqueous solutions is/are ?
(A) NaH_2PO_4 and Na_2HPO_4 (B) $NaHCO_3$ and NaOH.
(C) Na_2HPO_3 and NaOH (D) $NaHSO_4$ and NaOH.

Section-3 : (One Integer Value Correct Type.)
This section contains 6 questions. Each question, when worked out will result in one integer from 0 to 9 (both inclusive)

14. $M + (X + Y)NH_3 \longrightarrow [M(NH_3)_x]^{2+} + 2[e(NH_3)_4]^-$; where M = alkaline earth metal.
Value of x is.... .

15. How many of the following are correctly matched :
Hydration energy : $Li^+ > Na^+ > K^+ > Rb^+ > Cs^+$
Mobility of ions (aq) : $Li^+ > Na^+ > K^+ > Rb^+ > Cs^+$
Density : Li < Na < K < Rb < Cs
Reaction with N_2 : Li < Na < Rb < Cs < K
Reducing nature of gas phase : Li < Na < K < Rb < Cs

Reducing nature in aq. phase : Li > Na > K > Rb > Cs

16. How many of the following statements are correct ?
(a) BeO is amphoteric in nature.
(b) $LiHCO_3$ is not found in solid state.
(c) K_2O_2 is diamagnetic but KO_2 is paramagnetic.
(d) White phosphorous react with castic soda and gives phosphine gas.
(e) $AlCl_3$ is soluble in excess of NaOH and form sodium meta aluminate.
(f) Anhydrous potassium nitrate on heating with potassium metal gives potassium oxide and nitrogen gas.
(g) Lithium chloride is highly soluble in water.
(h) Hydrated magnesium chloride on heating in dry air gives anhydrous $MgCl_2$.

17. How many of the following orders are correct :

(A) $Be(OH)_2 < Mg(OH)_2 < Ca(OH)_2 < Ba(OH)_2$	Basic character
(B) $BaCO_3 > SrCO_3 > CaCO_3 > MgCO_3$.	Decomposition temperature
(C) $Na^+ > Mg^{2+} > Li^+ > Be^{2+}$	Size
(D) $Li_2CO_3 > Na_2CO_3 > K_2CO_3 > Rb_2CO_3 > Cs_2CO_3$	Water solubility
(E) $Na_2O_2 < K_2O_2 < Rb_2O_2 < Cs_2O_2$	Stability
(F) $LiHCO_3 < NaHCO_3 < KHCO_3 < RbHCO_3 < CsHCO_3$	Stability
(G) NaF < NaCl < NaBr < NaI	Melting point
(H) $Na_2O_2 < KO_2 < O_2[AsF_4]$	O–O bond length

18. How many of the following bicarbonates are solid in nature?
$LiHCO_3$, $NaHCO_3$, $KHCO_3$, $RbHCO_3$, $CsHCO_3$, $CsHCO_3$, $Be(HCO_3)_2$, $Mg(HCO_3)_2$, $Ca(HCO_3)_2$, $Sr(HCO_3)_2$, $Ba(HCO_3)_2$

19. How many types of products are formed when $LiNO_3$ and $NaNO_3$ are heated at 500ºC

SECTION-4 : Comprehension Type (Only One options correct)

This section contains 1 paragraph, describing theory, experiments, data etc. 3 questions relate to the paragraph. Each question has only one correct answer among the four given options (A), (B), (C) and (D).

Paragraph for Question Nos. 20 to 22

Alkali metals oxide are obtained by combustion of the metals. Although Na normally gives Na_2O_2, it will take up further oxygen at elevated pressure and temperatures to form NaO_2. The per and superoxides of the heavier alkalies can also be prepared by passing stoichiometric amounts of oxygen into their solution in liquid ammonia.
The different alkali metal oxides can be distinguished by reaction with water. The superoxides reacts with CO_2 and give oxygen gas. The stability of per and superoxides is based upon that larger cation can stablise larger anion, due to larger lattice energy.
Alkali metals dissolve in liquid ammonia. Dilute solutions are dark blue in colour but as the concentration increases above 3M, the colour changes to copper bronze and the solution acquires the metallic lusture due to the formation of metal ions clusters. The solution of alkali metals in liquid ammonia are good conductors of electricity due to the presence of ammoniated cations and ammoniated electrons. However, the conductivity decreases as the concentrations increases, since ammoniated electrons and ammoniated cation associate.

20. Solution of sodium metals in liquid ammonia is strongly reducing due to the presence of :
(A) Sodium hydride (B) Sodium atoms (C) Sodium amide (D) Solvated electrons.

21. KO_2 is used in oxygen cylinders in space and submarines because it.
(A) Eliminates moisture (B) Absorbs CO_2 only
(C) Absorbs CO_2 and increases O_2 contents (D) Produces ozone.

22. Select the correct choice for alkali metal oxides.
(A) Metal oxides reacts with water forming only metal hydroxides
(B) Metal peroxides reacts with warm water forming metal hydroxides and oxygen gas
(C) Metal superoxides reacts with water forming metal hydroxide, Hydrogen peroxide and O_2 gas
(D) All of these

SECTION-5 : Matching List Type (Only One options correct)

This section contains 1 questions, each having two matching lists. Choices for the correct combination of elements from List-I and List-II are given as options (A), (B), (C) and (D) out of which one is correct

23. Match the reactions given in **List I** with the main products obtained and given in **List II** and select the correct answer using the code given below the lists.

	List – I		**List - II**
	(Reaction at given temperature)		**(Reaction involve)**
(P)	$CaSO_4.2H_2O \xrightarrow{200°C,\ \Delta}$	(1)	Formation of lime
(Q)	$CaSO_4.2H_2O \xrightarrow{1100°C,\ \Delta}$	(2)	Setting of plaster of paris
(R)	$2CaSO_4.H_2O + H_2O \xrightarrow{\text{room temp.}}$	(3)	Formation of burnt plaster
(S)	$CaSO_4.2H_2O \xrightarrow{120°C,\ \Delta}$	(4)	Formation of plaster of paris

Code :

	P	Q	R	S		P	Q	R	S
(A)	1	3	4	2	(B)	4	1	2	3
(C)	3	1	2	4	(D)	4	2	1	3

Practice Test-2 ((IIT-JEE (ADVANCED Pattern))

OBJECTIVE RESPONSE SHEET (ORS)

Que.	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Ans.										
Que.	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
Ans.										
Que.	**21**	**22**	**23**							
Ans.										

APSP Answers

PART - I

1.	(4)	**2.**	(3)	**3.**	(4)	**4.**	(4)	**5.**	(4)
6.	(1)	**7.**	(2)	**8.**	(2)	**9.**	(3)	**10.**	(2)
11.	(3)	**12.**	(2)	**13.**	(2)	**14.**	(3)	**15.**	(3)
16.	(4)	**17.**	(3)	**18.**	(2)	**19.**	(4)	**20.**	(3)
21.	(2)	**22.**	(3)	**23.**	(4)	**24.**	(4)	**25.**	(1)
26.	(2)	**27.**	(2)	**28.**	(4)	**29.**	(4)	**30.**	(2)

PART-II

1.	(A)	**2.**	(A)	**3.**	(D)	**4.**	(C)	**5.**	(D)
6.	(C)	**7.**	(B)	**8.**	(A)	**9.**	(B)	**10.**	(C)
11.	(C)	**12.**	(D)	**13.**	(D)	**14.**	(C)	**15.**	(B)
16.	(D)	**17.**	(A)	**18.**	(C)	**19.**	(B)	**20.**	(AD)
21.	(C)								

PART - III

1.	(B)	**2.**	(D)	**3.**	(B)	**4.**	(D)	**5.**	(A)
6.	(B)	**7.**	(A)	**8.**	(ABCD)	**9.**	(BCD)	**10.**	(ABC)
11.	(AD)	**12.**	(AC)	**13.**	(AC)	**14.**	6	**15.**	2
16.	6.	**17.**	**5** (Except D,G,H)			**18.**	4	**19.**	4
20.	(D)	**21.**	(C)	**22.**	(D)	**23.**	(C)		

APSP Solutions

PART - I

1. Down the group size increases and therefore, attraction between valence shell electron and nucleus decreases and thus ionisation energy decreases.

2. (1) Down the group, the atomic size increases with increasing atomic number and so attraction for shared pair of electrons decreases. Hence electronegativity decreases.
(2) Down the group, the atomic size increases with increasing atomic number and so attraction between valence electron and nuclear decreases. Hence ionization energy decreases.
(3) Down the group atomic size increases with increase in number of atomic shells while effective nuclear charge remains constant.
(4) Down the group atomic size increases with increase in number of atomic shells and therefore, the strength of metallic bond decreases. So melting point decreases.

3. Alkali metals have low ionisation energy.

4. All are wrong. The solution has strong reducing nature and coloured due to ammoniated electron. Dilute solution is paramagnetic whereas concentrated solution is diamagnetic.

5. (2) Smaller cation and higher charge attracts more numbers of water molecules.
(3) Periodic property
(4) Except Li^+, due to bigger size of ions they have low hydration enthalpies. Hence except lithium, all alkali metal halides do not form hydrates.

6. **S_1 :** Li^+ being smaller have high polarising power and I^- being larger have high polarisability. So it is most covelent among alkali metal halides according to Fajan's rule.
S_2 : The IE1 of potussium atom is less then sodium atom.
S_3 : The presence of transition metals like iron and other impurities catalyses the decompositon of deep blue solution forming amide and liberating H_2.
S_4 : Two opposing tendencies exists. With greater charge and smaller size of cation, lattice energy increases which tends to increase the melting point; while increase in covalent character causes a decrease in melting point. Hence, no unique generalised trend may be stated for melting points. (Students need not worry about or memorise such experimental data).

7. The reaction of alkali metals with water becomes increasingly violent on descending the group on account of their decreasing ionisation energies with increasing atomic size. So, the order of reactivity is: Li < Na < K < Rb.

8. $2Na + O_2 \longrightarrow Na_2O_2$

9. They have weak metallic bond because of one valence electron per atom. So they have low melting points.

10. They easily lose valence shell electron because of their low ionisation energies, on account of their bigger atomic sizes. So they behave as strong reducing agents.

11. (1) Factual
(2) Hydration energy $\propto \dfrac{1}{\text{size of cation}}$.
(3) Both are diagonally related; because of more positive charge on Mg, Mg^{2+} is smaller than Li^+.
Li^+ = 76 pm, Mg^{2+} = 72 pm.
(4) Salt of weak base and strong acid, thus easily hydrolysed in water giving acidic solution.

12. $Be + Air \xrightarrow{T > 1000°C} BeO + Be_3N_2$ (white powder)
$Be_3N_2 + 6H_2O$ $3Be(OH)_2$ (white precipitate) + $2NH_3$ (Colourless gas)

13. $KNO_3 \xrightarrow{Heat} KNO_2 + \frac{1}{2}O_2$
$C + O_2 \longrightarrow CO_2$

14. $2Na + O_2 \xrightarrow{Heat} Na_2O_2$; $2Na_2O_2 + 2CO_2 \longrightarrow 2Na_2CO_3 + O_2$

15. $K_2O + H_2O \longrightarrow 2\ KOH \longrightarrow K^+ + OH^-$.
The resulting solution is basic due to the presence of OH^-.

16. $K + O_2 \xrightarrow{burning} KO_2$.

17. Sodium hydroxide is manufactured by the electrolysis of brine using Castner-Kellner cell.

18. (1) $Na_2O + H_2O \longrightarrow 2\ NaOH$
(2) 2 Na/Hg + 2 H_2O (Castner-Kellner cell) $\longrightarrow$ 2NaOH + 2 Hg + H_2.
(3) $Na_2O_2 + 2H_2O \longrightarrow 2\ NaOH + H_2O_2$
(4) $Na_2CO_3 + 2H_2O \rightleftharpoons 2NaOH + H_2CO_3$

19. (1), (2) & (3) reacts with water being more basic than water.

20. Isoelectronic species have same number of electrons.

21. All alkali metal hydrides are ionic in nature and react with water according to the reaction ;
$NaH + H_2O \longrightarrow NaOH + H_2$.

22. $Mg_3N_2 + 6H_2O \longrightarrow 3\ Mg(OH)_2 + 2NH_3$

23. True statement. The CsI, because of bigger cation (Cs^+) and bigger anion (I^-), has smaller hydration enthalpy. As a result, it does not exceed its lattice energy; so CsI is insoluble in water.

24. (1) Lithium show exceptional behavior in reaction directly with nitrogen of air to form the nitride, Li_3N.
(2) Smaller cation (Li^+) polarises bigger anion (Cl_3^{2-}) liberating CO_2 gas. So it has the lowest thermal stability.
(3) The solubility of the alkali metal hydroxides increases down the group from Li to Cs. This is because of the fact that down the group with increasing size of cation, the lattice energy as well as hydration energy also decreases but the change in lattice energy is more as compare to that of hydration energy.

25. $NaNO_3$ is not used as gun powder because it is hygroscopic in nature and becomes wet by absorbing water molecules from the atmosphere. Therefore, (1) option is correct.

26. Na_2SO_4.

27. Baking powder used to make cake is a mixture of starch, $NaHCO_3$ and $Ca(H_2PO_4)_2$. The function of $Ca(H_2PO_4)_2$ is being acidic in nature and gives CO_2 when moistened with $NaHCO_3$.

28. $Ba(NO_3)_2$ results a neutral solution as it is the salt of strong acid, HNO_3 and strong base, $Ba(OH)_2$.

29. Methanides give CH_4 on reaction with H_2O.
$Al_4C_3 + 12H_2O \longrightarrow 4Al(OH)_3 + 3CH_4$; $Be_2C + 4H_2O \longrightarrow 2Be(OH)_2 + CH_4$

30. Factual.

PART - III

1. **S_1 :** Because of the formation of an oxide film on their surface.
S_2 : Due to the formation of metal ion clusters.
S_3 : As the basicity (i.e. electropositive character) of alkaline earth metals increases, their reactivity towards water increases.
S_4 : Oxides and hydroxides of alkaline earth metals are less ionic and basic. This is due to increased nuclear charge and smaller size.

2. (A) Bigger anion is stabilised by bigger cation through lattice energy effect.
(B) Because of their high reactivity towards air and water on account of their higher electropositive character

(C) All alkali metals are highly basic in nature and, therefore, their hydrides are ionic solids with high melting points.
(D) In concentrated solution, unpaired electrons with opposite spins paired up-forming the solution diamagnetic.

3. $2\ Na + O_2(air) \xrightarrow{350^oC} Na_2O_2\ (X)$

$2\ CO_2 + 2\ Na_2O_2 \longrightarrow 2\ Na_2CO_3 + O_2\ (Y)$

Note : $Na_2O_2 + O_2 \xrightarrow[300\ atm]{450^oC} 2\ NaO_2$; $Na + O_2$ (limited amount) $\xrightarrow{180^oC} Na_2O$

4. $NaCl \longrightarrow Na^+ + Cl^-$; $2\ Cl^- \longrightarrow Cl_2 \uparrow + 2e^-$
$HOH \longrightarrow H^+ + OH^-$; $2H^+ + 2e^- \longrightarrow H_2 \uparrow$; $Na^+ + OH^- \longrightarrow NaOH$.

5. $NH_3 + H_2O + CO_2 \longrightarrow (NH_4)_2CO_3 \xrightarrow{CO_2} NH_4HCO_3$
$NH_4HCO_3 + NaCl \longrightarrow NaHCO_3 + NH_4Cl$.
$2\ NaHCO_3 \xrightarrow[1373\ K]{Heat} Na_2CO_3 + CO_2 + H_2O$

6. (B) $CaO + 3\ C \xrightarrow{\Delta} CaC_2 + CO$.

7. $CaSO_4.\ 2\ H_2O \xrightarrow[120^oC]{393\ K} 2\ CaSO_4.H_2O$ (Calcium sulphate hemihydrate).

8. (A) Very dilute solutions of the metals are paramagnetic, with approximately one unpaired electron per metal atom (corresponding to one solvated electron per metal atom); this paramagnetism decreases at higher concentration because of the association of unpaired electrons of opposite spins.
(B) According to the cavity concept, they occupy far greater volume than that expected from the sum of the volumes of metal and solvent and, therefore, these dilute solutions are of much lower density than pure solvent.
(C) Conduction is due mainly to the presence of solvated electrons. As the solutions are made more concentrated, the molar conductivity at first decreases, reaching a minimum at about 0.05 molar; thereafter, it increases again until in saturated solutions (it is comparable to that of the metal).
(D) Evaporation of the ammonia from solutions of alkali metals yields the metal, but with alkaline earth metals evaporation of ammonia gives hexammoniates of the metals, $[M(NH_3)_6]^{2+}$.

9. (A) The alkali metals dissolve in liquid ammonia giving blue solutions.

$M + (x + y)\ NH_3 \longrightarrow [M(NH_3)_x]^+ + [e(NH_3)_y]^-$

The blue colour, corresponding to a broad absorption band near 1500 nm that tails into the visible range, is attributed to the solvated electron.
(B) According to the cavity concept, they occupy far greater volume than that expected from the sum of the volumes of metal and solvent.
(C) The solution of metals in liquid ammonia act as powerful reducing agents (it even reduces the aromatic ring)

$GeH_4 + e^- \longrightarrow GeH_2^- + H_2$.

(D) In the presence of impurities or transition metals like Fe; MNH_2 and H_2 gas are formed.

$M + NH_3 \longrightarrow MNH_2 + \frac{1}{2} H_2$

10. (A) $P_4 + 3\ NaOH + 3\ H_2O \longrightarrow PH_3 + 3\ NaH_2PO_2$
(B) $4S + 6\ NaOH \xrightarrow{\Delta} Na_2S_2O_3 + 2\ Na_2S + 3\ H_2O$
(C) $3\ Cl_2 + 6\ NaOH \longrightarrow 5\ NaCl + NaClO_3 + 3\ H_2O$
(D) $2B + 6\ NaOH \longrightarrow 2\ Na_3BO_3 + 3\ H_2$

11. (A) $3NaN_3 + NaNO_2 \longrightarrow 2Na_2O + 5N_2$.
(B) False $\rightarrow$ Glauber's salt ($Na_2SO_4.10H_2O$) effloresces in dry air.
(C) $2\ KO_2 + S \xrightarrow{\Delta} K_2SO_4$.
(D) Form soluble double sulphate, $(NH_4)_2SO_4.CaSO_4.H_2O$ (soluble complex).

12. (A) $CaCO_3 + H_2O + CO_2 \longrightarrow Ca(HCO_3)_2$ soluble.
(B) Sodium is more basic (i.e. more ionic) in nature; so Na_2CO_3 is thermally stable towards heat. It does not decompose to give Na_2O and CO_2

(C) Li is least basic (i.e. more covalent) in nature; so Li_2CO_3 is thermally unstable.
(D) Presence of $CaCl_2$ or $CaSO_4$ in water causes permanent hardness. Temporary hardness of water is due to the presence of bicarbonates of Ca^{2+} and Mg^{2+}.

13. (A) Both are acid salts; so they can exist together in aqueous solution.
(B), (D) A base (NaOH) and an acid salt ($NaHSO_4$ and $NaHCO_3$) cannot exist together in solution.
Acid + base $\longrightarrow$ salt + water.
(C) Na_2HPO_3 is a neutral salt; so it does not further react with NaOH.

14. When alkaline earth metal except Be, Mg is dissolved in liquid NH_3, we get hexaammoniated metal ion.

15.

Hydration energy :	$Li^+ > Na^+ > K^+ > Rb^+ > Cs^+$
Mobility of ions (aq) :	$Li^+ < Na^+ < K^+ < Rb^+ < Cs^+$
Density :	Li < K < Na < Rb < Cs
Reaction with N_2 :	Li > Na > K > Rb > Cs
Reducing nature of gas phase :	Li < Na < K < Rb < Cs
Reducing nature in aq. phase :	Li > Cs > Rb > K > Na

16. (a), (b), (c), (d), (e) & (f) are correct.
(a) BeO is amphoteric in nature becuase it reacts with acid as well as base.
(b) $LiHCO_3 \xrightarrow{\Delta} Li_2CO_3 + H_2O + CO_2$
(d) $H_2O + NaOH + P_4 \longrightarrow NaH_2PO_2 + PH_3$
(e) $AlCl_3 + 4NaOH \text{ (excess)} \longrightarrow NaAlO_2 + 2H_2O + 3NaCl$
(f) $KNO_3 + K \longrightarrow K_2O + N_2$
(h) $MgCl_2.6H_2O \longrightarrow MgO + HCl + H_2O$.

17. **5** (Except D,G,H)

18. Only $NaHCO_3$, $KHCO_3$, $RbHCO_3$, $CsHCO_3$ are present in solid form.

19. $LiNO_3 \xrightarrow{\Delta} Li_2O + NO_2 + O_2$
$NaNO_3 \xrightarrow{\Delta} NaNO_2 + O_2$

20. Here solvated electrons acts as a reducing agent.

21. $4KO_2 + 3CO_2 \longrightarrow 2K_2CO_3 + 3O_2$

22. (A) $M_2O + H_2O \longrightarrow 2MOH$
(B) $M_2O_2 + H_2O \longrightarrow 2MOH + 1/2O_2$
(C) $2MO_2 + 2H_2O \longrightarrow 2MOH + H_2O_2 + O_2$

23. $\underset{\text{(Gypsam)}}{CaSO_4.2H_2O} \xrightarrow{120°C,\ \Delta} \underset{\text{(plaster of paris)}}{CaSO_4.\frac{1}{2}H_2O} \xrightarrow{200°C,\ \Delta} \underset{\text{(burnt or dead plaster)}}{CaSO_4} \xrightarrow{1100°C,\ \Delta} \underset{\text{(lime)}}{CaO} + SO_3$