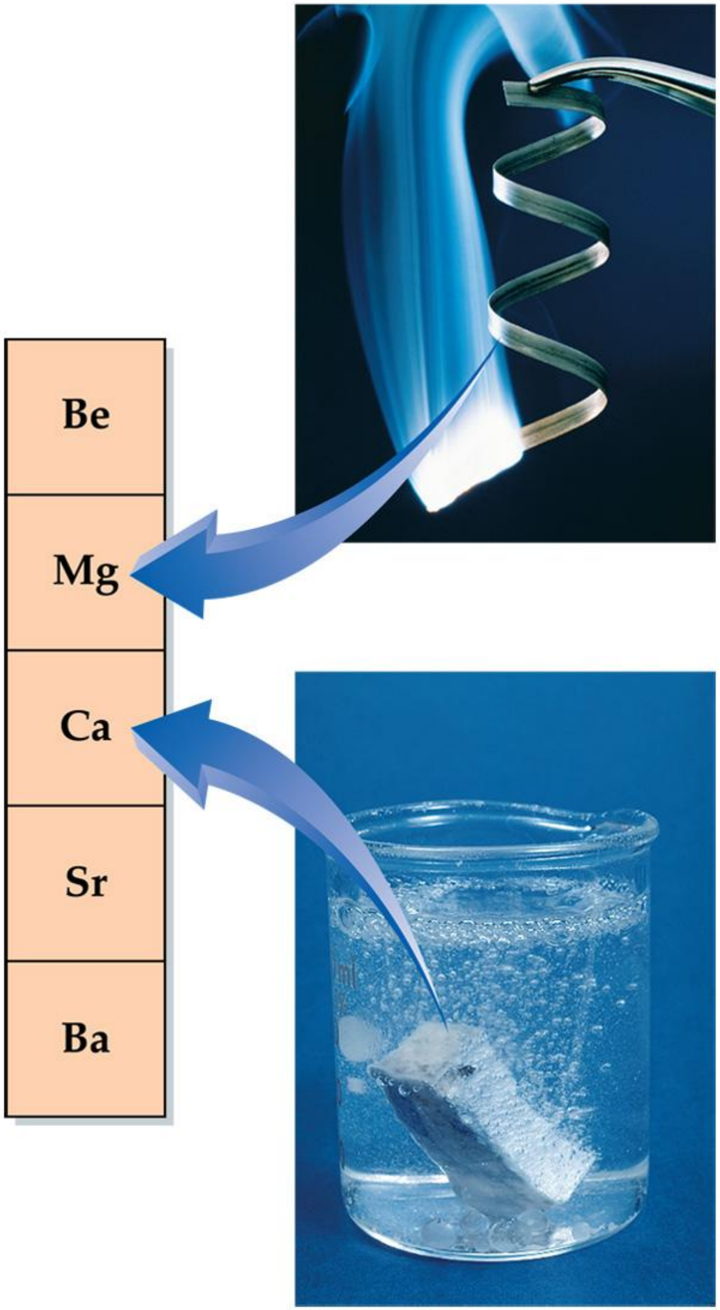
Alkaline Earth Metals



Alkaline Earth Group

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General properties

- Group IIA shows the same general trends of increasing atomic and ionic sizes and decreasing ionization energies from top to bottom as does Group IA.

General properties

- Except for Be, the metals have similar properties.
  - They readily react to produce cations with +2 charge,
  - They are good reducing agents.

General properties

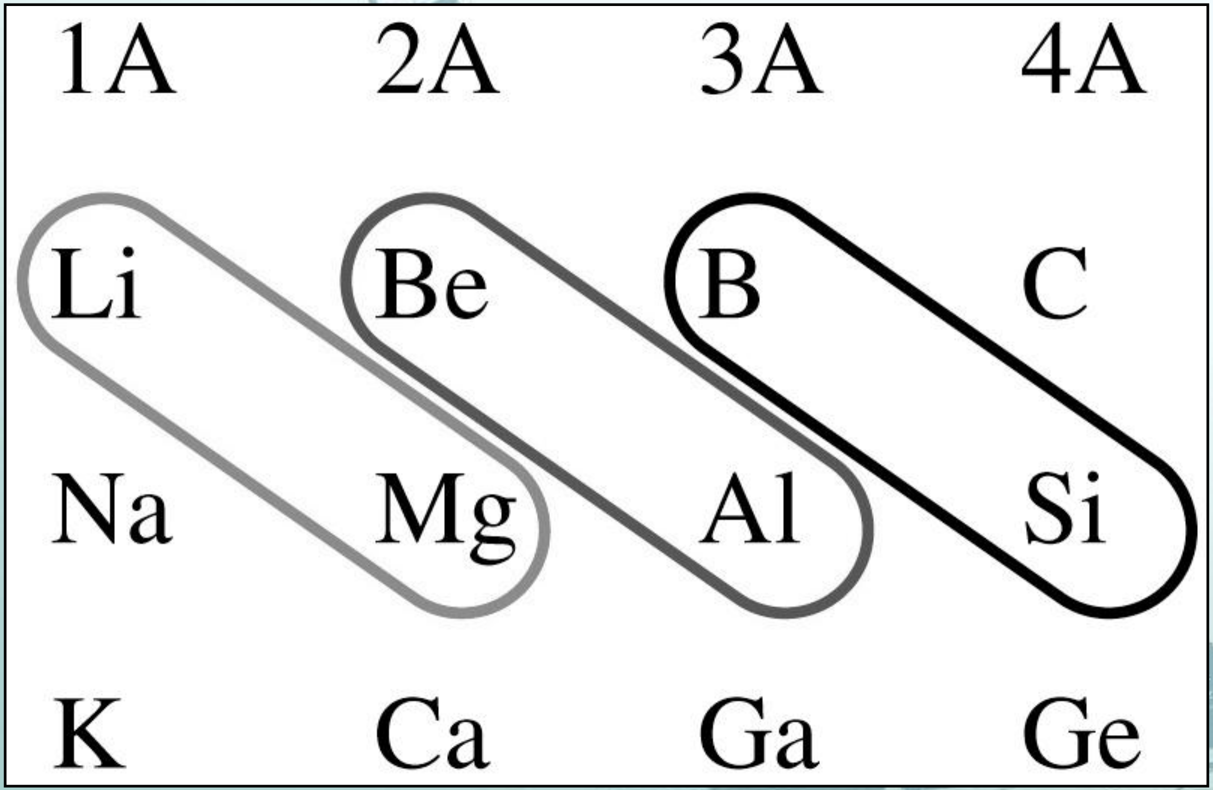
- Except for Be, the metals have similar properties
  - As the cation size increases, the interionic attractions (anion-cation interaction) that hold the crystalline solid together decrease in strength and the solubilities of the compounds in water increases

General properties

- The hydroxides and oxides are strong bases but they are not very soluble.
  - The solubilities of the metal hydroxides of Group IIA in water increase from top to bottom.

General properties

- Be is more like Al than other alkali earth metals – diagonal relationship.



General properties

- Almost alkaline earth metals are hydrated

  Ion density >>> → Σ hydrated water molecule >>>

- The salt of alkaline earth slightly soluble

  Monovalent salt → soluble

  Divalent salt → slightly soluble

Reactions Of The Alkaline Earth Metals

- Reactions with water is more vigorous toward the bottom of the family.

$$M(s) + 2\ H_2O\ (\ell) \rightarrow M(OH)_2(aq) + H_2(g)$$

M = Ca, Sr, Ba

Reactions Of The Alkaline Earth Metals

- Mg does react with steam, but MgO is formed rather than $Mg(OH)_2$.

$$Mg(s) + 2\ H_2O(g) \rightarrow MgO(s) + H_2(g)$$

Reactions Of The Alkaline Earth Metals

- All alkali earth metals react with dilute acids to displace hydrogen.

$$M(s) + 2\,H^{+}(aq) \rightarrow M^{2+}(aq) + H_2(g)$$

Reactions Of The Alkaline Earth Metals

The following reactions occur with Mg, Ca, Sr, Ba, NOT with Be.

1 $M(s) + X_2(g) \rightarrow MX_2(s)$

$X_2 = F_2, Cl_2, Br_2, I_2$

2 $M(s) + O_2(g) \rightarrow 2\underline{MO}(s)$

3 $M(s) + N_2(g) \rightarrow M_3N_2(s)$

Physical properties

- Have higher melting points, are harder and are denser than potassium and sodium
- When put in flame:
  - Mg : white
  - Ca : dark red
  - Sr : crinsom
  - Ba : light green

Beryllium

Sources:

- beryl mineral ($Be_3Al_2Si_6O_{18}$ / $Be_3Al_2(SiO_3)_6$

- bertrandite [$4BeO.2SiO_2.H_2O$]

  Light green-bluish from beryl → aquamarine

  Deep green → emerald → ~ 2% Cr(III)

Beryllium

Production:

1. Extraction from its ore (complex procedure)

   Beryl ore are heated by hexafluorosilicate (Na_2SiF_6) at 700^oC → beryllium fluoride / beryllium chloride → electrolyzed in molten NaCl

   $BeCl_2$ (in molten NaCl) → Be(*s*) + Cl_2(*g*)

Beryllium

Production:

2. Reduction of beryllium fluoride by magnesium ($T \approx 1300^{o}C$)

$$BeF_2(s) + Mg(\ell) \rightarrow MgF_2(s) + Be(s)$$

Beryllium

1-st & 2-nd ionization energy of Be>other alkaline earth metals?

What is the coordination number of Be^{2+}?

Geometri shape of BeH_2, $BeCl_2$ $BeBr_2$?

Beryllium

- Beryllium oxide & beryllium halides → covalent properties,
  $[Be(H_2O)_4]^{2+}$,$[BeF_4]^{2-}$,$[BeCl_4]^{2-}$
- Beryllium amphoteric

$$H_2O(\ell) + BeO(s) + 2\,H_3O^+(aq) \rightarrow [Be(H_2O)_4]^{2+}(aq)$$

$$H_2O(\ell) + BeO(s) + 2OH^-(aq) \rightarrow [Be(OH)_4]^{2-}(aq)$$

Beryllium

- Uses
- Spacecraft
- Aircraft
- Missiles
- X-rays

Magnesium

Sources :

- carnalite ($MgCl_2.KCl.6H_2O$) & dolomite ($MgCO_3.CaCO_3$)

  Carnalite compiler ratio: $Cl^-:Mg^{2+}:K^+:H_2O$ = 3 : 1 : 1 : 6 $\rightarrow KMgCl_3.6H_2O$
- brine (no 3. after Na^+ & Cl^-)

Magnesium

Production :

- Dow process
- calcinations of dolomite → calcinated dolomite (MgO.CaO) → reacted by ferrosilicon alloy

$$2[MgO.CaO](s)+FeSi(s)$$

$$\rightarrow 2\,Mg(\ell) + Ca_2SiO_4(s) + Fe\,(s)$$

Magnesium is distillated from the mixture

Magnesium

Uses

- Used on pyrotechnic, light on photographic
- Because of its weight just 1/3 of aluminum`s, magnesium is used in aircraft making, missile construction

Magnesium

- Alloy of Magnesium – Aluminum:

    95% Mg – 5% Al

        strength >>> weight<<< (strength/weight ratio>>>)

    5% Mg – 95% Al

        increase mechanical property & corrosion resistance

Magnesium

Uses

- Because of its reactivity >>>
  - sacrificial anode
  - cathode corrosion protection
- Reducing agent on the production of titanium, uranium, beryllium

Magnesium

Uses

- Magnesia milk (suspension solution of pure $Mg(OH)_2$ → antacid (neutralized stomach acid)
- Used on the production of organomagnesium compounds (Grignard reagent)

Fire by burning magnesium

Magnesium oxidized slowly at room temperature, violence at heating

2 Mg (*s*) + O_2 (*g*) → MgO (*s*)

Fire by burning magnesium

Burned magnesium metal can not be extinguished by conventional extinguisher.

Why ?

What should we do?

Fire by burning magnesium

Conventional extinguisher → CO_2 and H_2O

$2\,Mg(s) + CO_2(g) \rightarrow 2\,MgO(s) + C(s)$

fire is getting more violent

Fire by burning magnesium

Extinguish method:

- Graphite → react with burned magnesium → magnesium carbide

$$Mg(s) + C(s) \rightarrow MgC_2(s)$$

MgC_2 cover burned metal surface effectively & prevent further burning reaction

Fire by burning magnesium

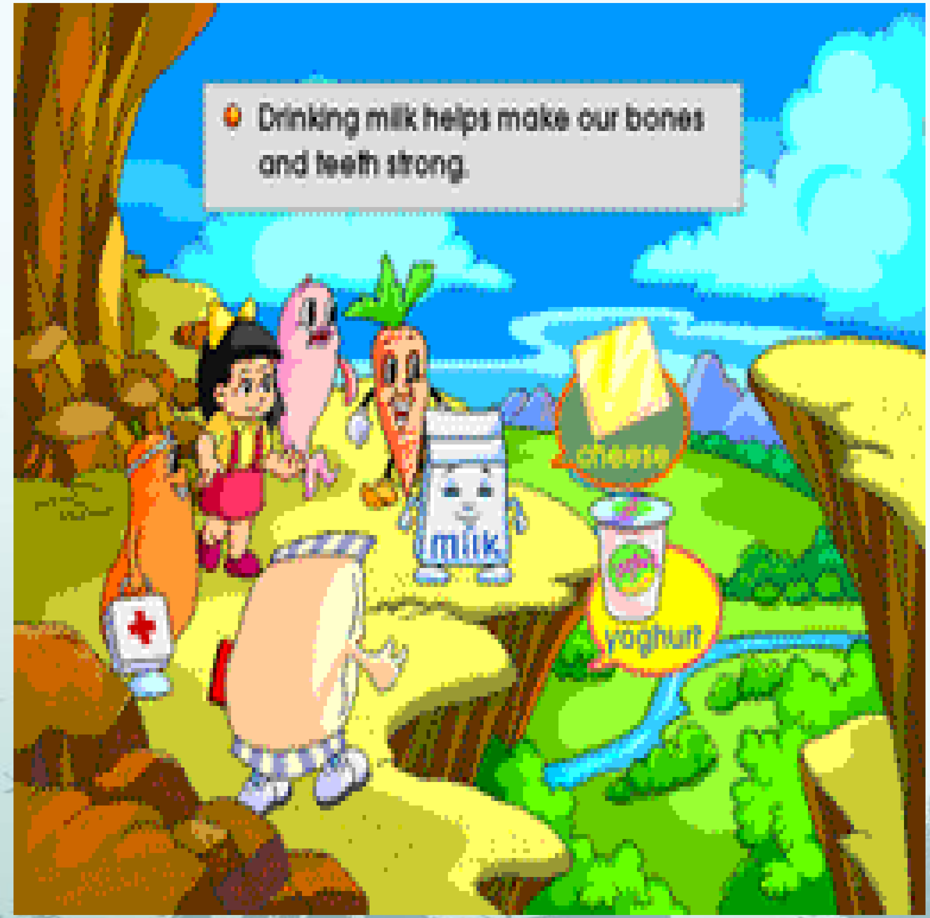
Extinguish method:

- NaCl melt on the burning temperature of magnesium → inert layer → cover burned metal surface prevent further contact with O_2, H_2O, and CO_2

Calcium

Uses

- Builds Strong bones and teeth
- Used in Milk
- Used to make plaster



Stronsium

Uses

- Flares
- To create a crimson color

Barium

Uses

- Medical Applications
- Glass making
- Rat poison
- Making Rubber

Radium

Uses

- Treating Cancer

Alkaline earth oxide

Be, Mg, Ca, Sr + O_2 → normal oxide

Ba + O_2 → peroxide

MgO :

- melting point >>>(2825^oC) → raw material of furnace lining
- good thermal conductor, but not for electric

Alkaline earth oxide

CaO:

- used on steel industry
- with water forms $Ca(OH)_2$ → neutralized soil acidity → too base

$$CaO(s) + H_2O(\ell) \rightarrow Ca(OH)_2(aq)$$

$$Ca(OH)_2(aq) + H_3O^+(aq) \rightarrow Ca^{2+}(aq) + 3H_2O(\ell)$$

$$CaCO_3(s) + H_3O^+(aq) \rightarrow Ca^{2+}(aq) + CO_2(g) + 3H_2O(\ell)$$

Alkaline earth oxide

1. Calsium karbonat ($CaCO_3$)

   The formation of lime cave, stalagtite dan stalagmite

   Reactions :

   $$CaCO_3(s) + CO_2(g) + H_2O(\ell) \rightleftharpoons Ca^{2+}(aq) + 2HCO_3^-(aq)$$

   $$Ca(HCO_3)_2\,(aq) \rightarrow CaCO_3(s) + CO_2(g) + H_2O(\ell)$$

Alkaline earth oxide

1. Calsium karbonat ($CaCO_3$)

   Calcium carbonate (antacid)

   reacts with stomach acid → CO_2 (*g*) + Ca^{2+}(*aq*)

   Ca^{2+} → *efek sembelit* (in contrast to Mg^{2+} → *memperlancar*)

Alkaline earth oxide

2. Magnesium sulfate ($MgSO_4.7H_2O$)

Other name : Epsom salt

Uses : laxative effect /*memperlancar*

Alkaline earth oxide

3. Calcium sulfate ($CaSO_4.2H_2O$)

Other name : gypsum

Uses : inflammable room separator

Alkaline earth oxide

3. Calcium sulfate ($CaSO_4.2H_2O$)

$$CaSO_4 \cdot 2H_2O \xrightarrow[\triangle]{100^{O}C} CaSO_4 \cdot 1/2H_2O(s) + 3/2H_2O(\ell)$$

$\Delta H = +446$ kJ/mol

(hemidrate, paris plaster)

$\downarrow + H_2O$

$$CaSO_4 \cdot 2H_2O$$

$H_2O(\ell) \rightarrow H_2O(g)$ $\Delta H = +44$ kJ/mol

Important Reactions of Ca Compounds

Calcination: $CaCO_3(s) \rightarrow CaO(s) + CO_2(g)$

quicklime or lime

Hydration: $CaO(s) + H_2O(\ell) \rightarrow Ca(OH)_2(s)$

slaked lime

Carbonation: $Ca(OH)_2 + CO_2(g) \rightarrow CaCO_3(s) + H_2O(\ell)$

- The three steps are combined and used to prepare chemically pure $CaCO_3(s)$ from limestone.

The Group IIA Metals And Living Matter

- Persons of average size have approximately 25 g of magnesium in their bodies.
- The recommended daily intake of magnesium for adults is 350 mg.
- Calcium is essential to all living matter. The human body typically contains from 1 to 1.5 kg of calcium – bones and teeth

The Group IIA Metals And Living Matter

- Strontium is not essential to living matter, but it is of interest because of its chemical similarity to calcium.
- Barium also has no known function in organisms; in fact the Ba^{2+} ion is toxic.

Diagonal Relationships: The Special Case Of Beryllium

In some of its properties, beryllium and its compounds resemble aluminium and its compounds.

1. Both Be and Al react with air to form oxide layer that protect the layer below from further contact with air

Diagonal Relationships: The Special Case Of Beryllium

In some of its properties, beryllium and its compounds resemble aluminium and its compounds.

2. Both Be and Al are amphoteric. Berilat and aluminat anions are formed from the reaction of Be and Al with concentrated hydroxide.

Diagonal Relationships: The Special Case Of Beryllium

In some of its properties, beryllium and its compounds resemble aluminium and its compounds.

3. The two carbide of Be and Al (Be_2C and Al_4C_3) react with water to form metane. While dicarbide(-2) of other alkaline earth react with water to form ethyne.

$$Be_2C(s) + 4H_2O(\ell) \rightarrow 2Be(OH)_2(s) + CH_4(g)$$

$$Al_4C_3(s) + 12H_2O(\ell) \rightarrow 4Al(OH)_3(s) + 3CH_4(g)$$