<u>Mg</u> not like Be or the rest of the group. It is intermediate between purely ionic and purely covalent.

Mg^{2+} is highly polarizing and therefore does form some non-ionic compounds in addition to ionic compounds

$Mg(OH)_2$ like $Be(OH)_2$ is more covalent than the other $M(OH)_2$ compounds which dissolve readily in H_2O to give basic solutions (ionic oxides are basic whereas covalent oxides, if they dissolve, are acidic)

(actually Be^{2+} and Mg^{2+} form amphoteric oxides)

Calcium, Strontium, Barium and Radium

These form a rather close-knit group with properties that vary gradually with increasing size $Ca \rightarrow Ra$

- electropositive nature increases
- hydration energies of the salts increase
- insolubility of most salts increase
- larger cations tend to stabilize larger anions
  O_2^{2-}, O_2^{-}, I_3^{-}

Binary Compounds of Group IIA

Oxides

MO   white, high-melting crystalline materials
      NaCl fcc structures

most important member is:

$$CaCO_3 \rightarrow CaO + CO_{2(g)}$$

$$\Delta H = 178.1 \text{ kJ/mol}$$

CaO is made on a vast scale for the cement industry (from limestone)

except for Mg^{2+} the following is true:

$$MO + H_2O \rightarrow M(OH)_2 + \text{heat}$$

strong bases!

$Mg(OH)_2$ is a weak base

Halides

all are ionic

MX_2 can be made from dehydration of hydrates $MX_2 \cdot xH_2O$ (X can vary)

Solubilities of MX_2 decrease as you go down the group except for MF_2 compounds which are more soluble for: $Ba^{2+} > Sr^{2+} > Ca^{2+} > Mg^{2+}$

Q Why?

A Mg^{2+} is rather small so contact with F^- is good in the crystal packing → stabilizes the crystal giving a high lattice energy & Ba^{2+} is large, does not make good contact with F^- in a crystal

Summary
Periodic Chemical Properties as developed in Chapter 8 are evident in Alkaline Earths, Group IIA

Be
1. covalent even with electronegative elements e.g. BeF_2, $[BeF_4]^{2-}$, $[Be(OH_2]^{2+}$
2. forms no simple Be^{2+} ionic compounds
3. forms four-coordinate compounds
4. forms covalent Be-C bonds as in BeR_2 (R = alkyl)
5. oxide BeO and $Be(OH)_2$ are amphoteric
6. halides $[BeX_2]_n$ are covalent polymers
7. hydride $[BeH_2]_n$ is also a covalent polymer

<u>Mg</u>

1. forms ionic substances that have partial ionic character
2. forms many ionic compounds with uncomplexed Mg^{2+}
3. MgO is basic and the hydroxide is only weakly basic
4. forms ionic MgX_2 halides
5. MgH_2 is only partially covalent

<u>Ca, Sr, Ba</u>

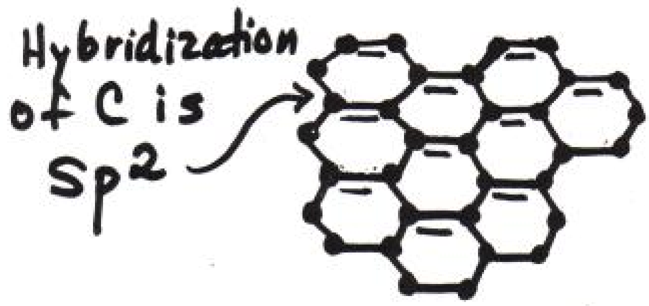
1. form only ionic substances
2. do not form covalent bonds
3. MO are basic and the $M(OH)_2$ are strong bases with increasing solubilities with larger cations
4. MH_2 are strongly H^- based, ionic compounds

Carbon

Allotropes (two main ones)

1. graphite $C_{(s)}$
2. diamond $C_{(s)}$

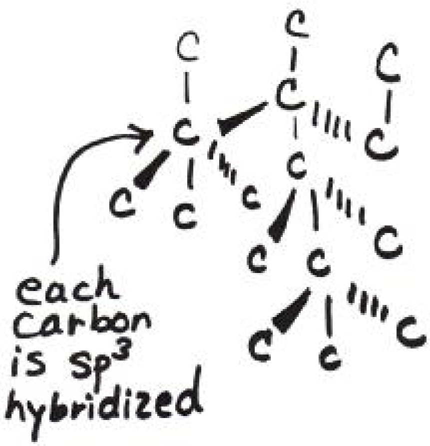
1. Graphite – sheets of carbon atoms linked in hexagon shapes



This is a sheet, held together by C-C bonds

- Rings of carbon atoms “lock” together; this allows them to conduct electricity in the sheet
- The next sheet or layer on top is held only by weak van der Waals forces

2. Diamond



- each carbon is tetrahedral (sp^3)
- the network is three-dimensional
- hard to break the C-C bonds so diamond is hardest substance known
- diamond is used as an abrasive (cutting tools)

Other forms of Carbon

3. Charcoal is mostly graphitic carbon but it is prepared by heating wood without oxygen

$$\text{cellulose (C, H, O)} \xrightarrow[\Delta]{} C + H_2O$$

Finely powdered charcoal is activated charcoal. It absorbs a variety of molecules from air and water so it is used in filters.

4. <u>Coke</u> is similar to charcoal but it is made by heating soft (bituminous) coal. Coke is used to reduce oxides to metals.

   coal (C, H) $\xrightarrow[\Delta]{}$ C + small chain hydrocarbons

5. <u>Carbon black</u> is finely divided carbon made by heating hydrocarbons or paraffins (wax).

   ex. $CH_4 + O_{2(g)} \rightarrow C_{(s)} + 2H_2O$
   limited supply only

6. <u>Fullerenes</u> C_{60}, C_{70}

   Buckminsterfullerene "Bucky-Balls"

   "Bucky-Balls", C_{60}, look like soccer balls. <u>Their shapes have 60 vertices and 32 faces with 20 hexagons and 12 pentagons</u>

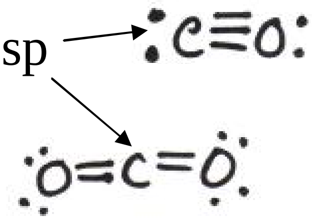
   C_{70} is similar but is "pinched" around the middle and is larger than C_{60}

Oxides of Carbon

A. CO carbon monoxide

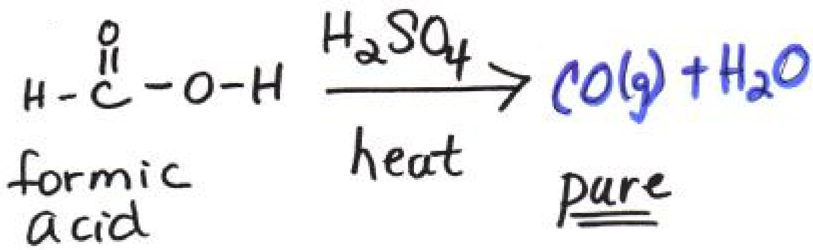
B. CO_2 carbon dioxide

sp



A. Carbon monoxide CO

- Preparation:



impure CO is found wherever fuels are burned – it is mixed with CO_2 and sometimes other hydrocarbons

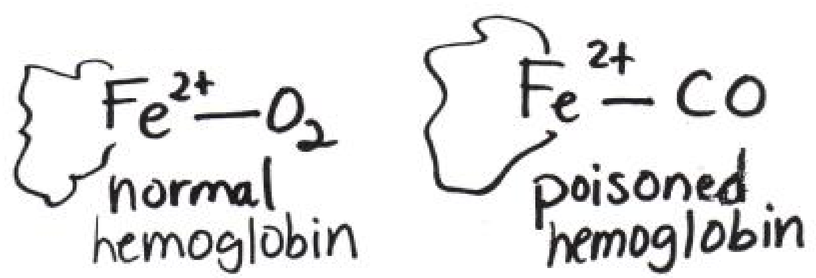
- Used as a fuel in the "water gas" reaction

$$C_{(s)} + H_2O_{(g)} \xrightarrow{1000\ ^{o}C} \boxed{\underset{\text{"water gas"}}{CO_{(g)} + H_{2(g)}}}$$

$$\boxed{\overset{\text{fuel}}{CO_{(g)} + H_{2(g)}}} + O_{2(g)} \xrightarrow{\text{burn}} CO_2 + H_2O$$

- Used as a reducing agent. CO is used to <u>reduce</u> metal oxides to metals.
  ex. $FeO + CO \xrightarrow[\Delta]{} Fe + CO_2$

- poisonous to red-blooded animals. Why? because CO is very poisonous to our respiratory cycle. It binds to the Fe^{2+} (heme) ion in hemoglobin and blocks it from carrying O_2 to the cells.



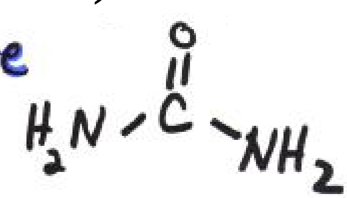
B. <u>Carbon dioxide CO_2</u>

- Preparations: (small-scale)
  (a) $2CO_{(g)} + O_{2(g)} \xrightarrow[\Delta]{} 2CO_{2(g)}$
  (burning of CO in air)
  (b) $2C_8H_{18} + 25\ O_2 \rightarrow 16CO_2 + 18H_2O$
  (formed by complete combustion of hydrocarbons)

- Industrial Production:
  CO_2 is a by-product of the Haber-Bosch process. A by-product is not a major product but a minor one.

  CO_2 is used to make urea
  Reaction of CO_2 to make urea:

  $$CO_{2(g)} + 2NH_{3(g)} \xrightarrow[185\ ^{o}C]{200\ atm} (NH_2)_2CO + H_2O$$
  (urea)

  structure
  

  Use of urea:
  Urea is a solid, unlike NH_3. It can be easily shipped into agricultural areas and mixed into the soil. It then slowly reacts with H_2O to give back NH_3 and CO_2.
  $(NH_2)_2CO + H_2O \rightarrow CO_2 + 2NH_3$

- Other Sources of CO_2
  by heating metal carbonates
  $CaCO_{3(s)} \xrightarrow{\Delta} CaO_{(s)} + CO_{2(g)}$
  (limestone) (lime)

lime or CaO (limestone is $CaCO_3$) is calcium oxide which is an important chemical

16-18 million tons of lime are produced annually in the U.S.

What is it used for?

- metallurgical industry
- chemical industry
- waste water treatment
- “scrubbing” SO_2 from smoke stack gases
- making cement

Cement – Portland cement

lime powder (CaO)

+ sand (SiO_2)

+ clay ($SiO_2 \cdot Al_2O_3$ oxides) $\xrightarrow{\text{heat}}$

Portland Cement

C-Si-O-Si-O-Si-…. strong bonds