



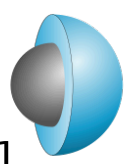
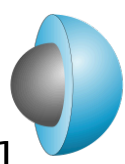
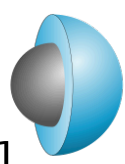
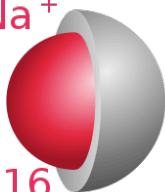
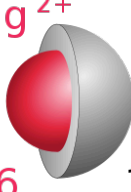

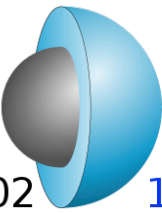
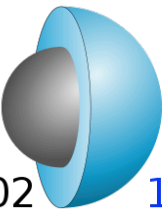
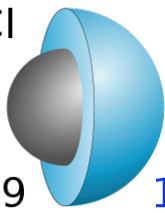
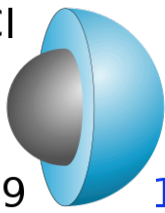

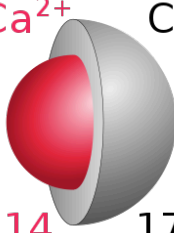

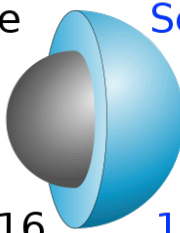
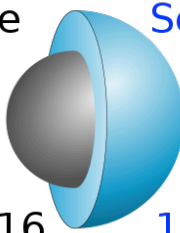
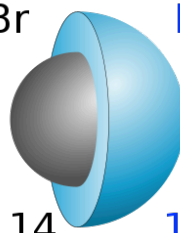
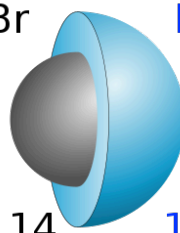
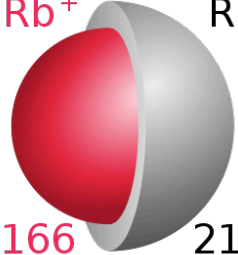


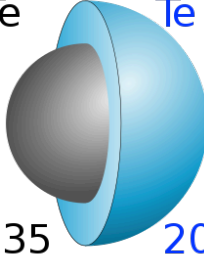
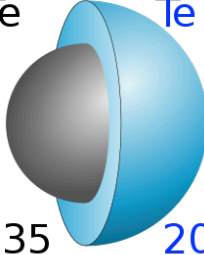
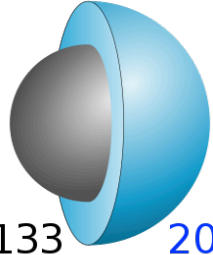
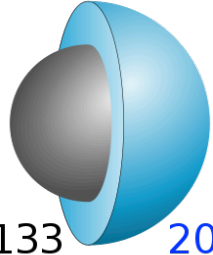


Mg not like Be or the rest of the group. It is intermediate between purely ionic and purely covalent.

Mg^{2+} is highly polarizing (relatively small size and high charge) and therefore does form some non-ionic compounds in addition to ionic compounds

In order to form ionic bonds an atom must lose electrons easily to become positively charged. The amount of energy is their ionization energy. The lower the ionization enthalpy, the easier it is to form a cation and thus an ionic bond. The ionization enthalpies of Alkali and Alkaline Earth metals are low compared to other groups in the periodic table, but there is a catch with Lithium and Beryllium (and to some extent Magnesium). They have the highest covalent character within their groups. The reason for this anomalous behavior is the unusual degree of attraction to the nucleus compared to other members of the group. **This is because they have their last electrons in a 2s orbital which is much closer to the nucleus compared to the other members of their series.** This leads to higher effective nuclear charge or stronger attraction from the nucleus and thus makes the removal of their electrons more difficult. This leads to bit of a higher ionization enthalpy and a but less ionic character.

Sizes of atoms and their ions in pm

Group 1		Group 2		Group 13		Group 16		Group 17	
Li^+  90	Li 134	Be^{2+}  59	Be 90	B^{3+}  41	B 82	O  73	O^{2-}  126	F  71	F^-  119
Na^+  116	Na 154	Mg^{2+}  86	Mg 130	Al^{3+}  68	Al 118	S  102	S^{2-}  170	Cl  99	Cl^-  167
K^+  152	K 196	Ca^{2+}  114	Ca 174	Ga^{3+}  76	Ga 126	Se  116	Se^{2-}  184	Br  114	Br^-  182
Rb^+  166	Rb 211	Sr^{2+}  132	Sr 192	In^{3+}  94	In 144	Te  135	Te^{2-}  207	I  133	I^-  206

$\text{Mg}(\text{OH})_2$ like $\text{Be}(\text{OH})_2$ is more covalent than the other $\text{M}(\text{OH})_2$ compounds in the group which dissolve readily in H_2O to give basic solutions (ionic oxides which are basic) whereas covalent oxides, if they dissolve, are acidic) (actually, the reality is that Be^{2+} and Mg^{2+} form amphoteric oxides)

Calcium, Strontium, Barium and Radium

These comprise 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

The solubility decreases down the group because the hydration enthalpy (tendency to be surrounded by water) decreases from Be^{2+} to Ba^{2+} as the size of the cation increases down the group. Sulfates, carbonates, nitrates etc.,

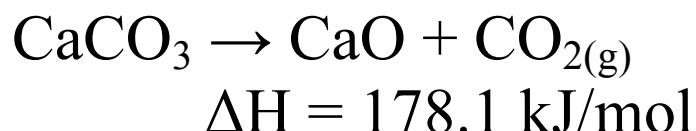
- larger cations tend to stabilize larger anions
 O_2^{2-} , O_2^- , I_3^-

Binary Compounds of Group IIA

Oxides

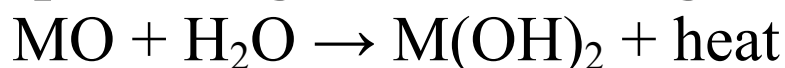
MO white, high-melting crystalline materials
NaCl fcc structures


most important member is:



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

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



 strong bases!

Mg(OH)₂ is a weak base

Magnesium hydroxide has limited solubility, meaning not very much is going to dissolve so it produces only a low concentration of **hydroxides**. Therefore it acts like a **weak base**.

Halides

all are ionic

MX_2 can be made from dehydration of hydrates $\text{MX}_2 \cdot x\text{H}_2\text{O}$ (the number of waters, x , can vary)

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

Q Why?

A Mg^{2+} is rather small so contact with F^- is good in the crystal packing \rightarrow 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 , $[\text{BeF}_4]^{2-}$, $[\text{Be}(\text{OH}_2)]^{2+}$
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 hydroxide $\text{Be}(\text{OH})_2$ are amphoteric
6. halides $[\text{BeX}_2]_n$ are covalent polymers
7. hydride $[\text{BeH}_2]_n$ is also a covalent polymer

Mg

1. forms ionic substances that have partial ionic character
2. forms many ionic compounds with uncomplexed Mg^{2+}
3. MgO is basic and the Mg(OH)_2 is only weakly basic due to low solubility
4. forms ionic MgX_2 halides
5. MgH_2 is partially covalent

Ca, Sr, Ba

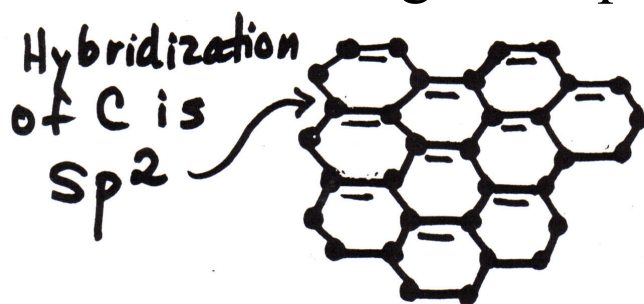
1. form only ionic substances
2. do not form covalent bonds
3. MO are basic and the M(OH)_2 are strong bases with increasing solubilities with larger cations
4. MH_2 are strongly H^- (hydride) based, ionic compounds

Carbon

Allotropes (two main ones)

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

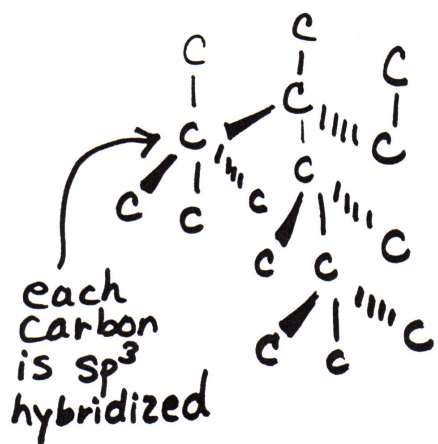
1. Graphite – sheets of carbon atoms linked in hexagon shapes



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

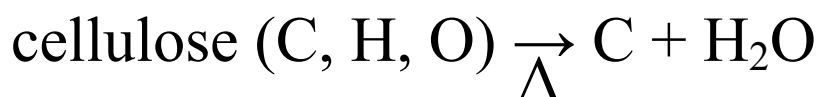
2. Diamond



- 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

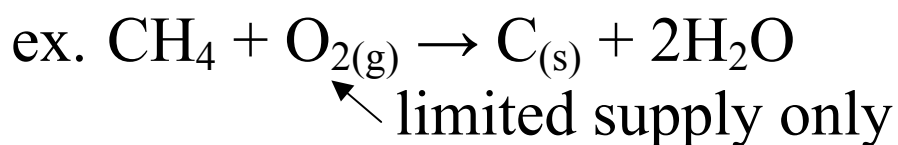


Finely powdered charcoal is activated charcoal. It absorbs a variety of molecules from air and water so it is used in filters.

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



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



6. Fullerenes $\text{C}_{60}, \text{C}_{70}$

Buckminsterfullerene “Bucky-Balls”

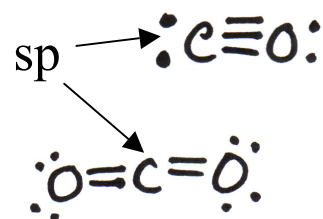
“Bucky-Balls”, C_{60} , look like soccer balls.
Their shapes have 60 vertices and 32 faces with 20 hexagons and 12 pentagons

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

Oxides of Carbon

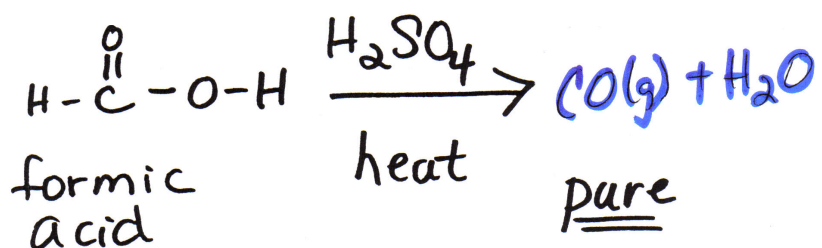
A. CO carbon monoxide

B. CO₂ carbon dioxide



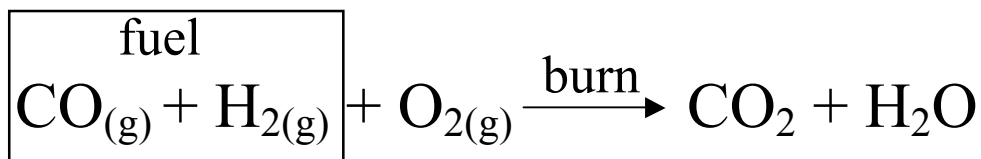
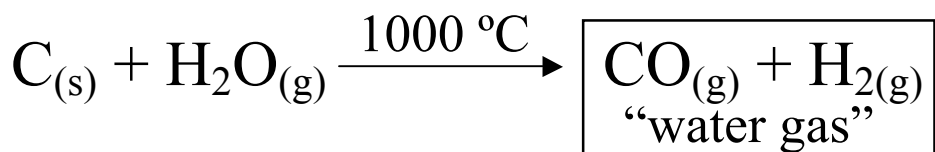
A. Carbon monoxide CO

- Preparation:

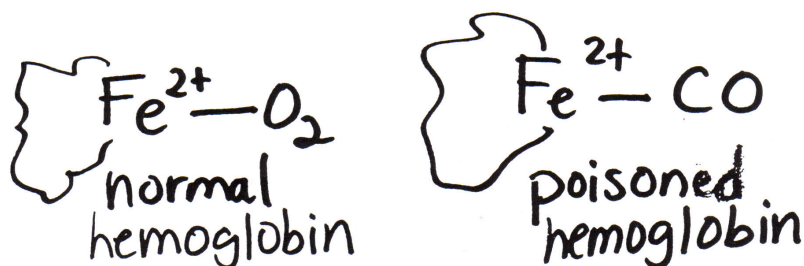


impure CO is found wherever fuels are burned – it is mixed with CO₂ and sometimes other hydrocarbons

- Used as a fuel in the “water gas” reaction



- Used as a reducing agent. CO is used to reduce metal oxides to metals.
ex. $\text{FeO} + \text{CO} \xrightarrow{\Delta} \text{Fe} + \text{CO}_2$
- 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.



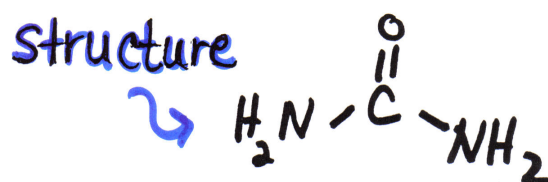
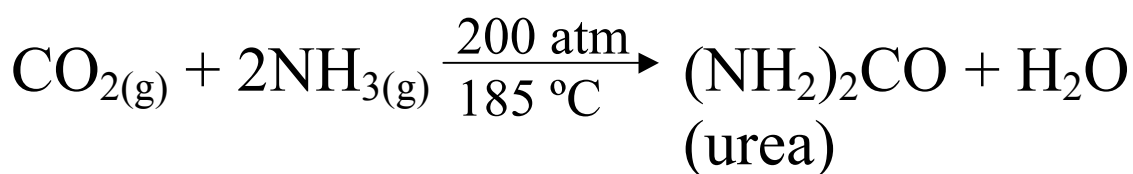
B. Carbon dioxide CO_2

- Preparations: (small-scale)
 - (a) $2\text{CO}_{(\text{g})} + \text{O}_{2(\text{g})} \xrightarrow{\Delta} 2\text{CO}_{2(\text{g})}$
(burning of CO in air)
 - (b) $2\text{C}_8\text{H}_{18} + 25 \text{O}_2 \rightarrow 16\text{CO}_2 + 18\text{H}_2\text{O}$
(formed by complete combustion of hydrocarbons)

- **Industrial Production:**
CO₂ is a by-product of the Haber-Bosch process. A by-product is not a major product but a minor one.

CO₂ is used to make urea

Reaction of CO₂ to make urea:



Use of urea:

Urea is a solid, unlike NH₃. It can be easily shipped into agricultural areas and mixed into the soil. It then slowly reacts with H₂O to give back NH₃ and CO₂.



- Other Sources of CO₂
by heating metal carbonates

$$\text{CaCO}_{3(s)} \xrightarrow{\Delta} \text{CaO}_{(s)} + \text{CO}_{2(g)}$$

(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 ($\text{SiO}_2 \cdot \text{Al}_2\text{O}_3$ oxides)

$\xrightarrow{\text{heat}}$

Portland Cement
 C-Si-O-Si-O-Si-.... strong bonds