Forming an Ionic Compound, Lewis Structures, Resonance Name KEY

1. The carbonate ion, CO_3^{2-}, is formed when carbon dioxide, CO_2 reacts with slightly basic cold water.

   a. Draw the Lewis dot structure for the carbonate ion and for carbon dioxide. Include any resonance structures.

   b. Describe the relative bond energy of the three C-O bonds in the carbonate ion.

   c. How does the bond energy of the carbon-oxygen bonds in carbon dioxide compare to the bond energy of the bonds in carbonate?

2. a. Use Needs, Available, Shared (show work) to draw Lewis structures for sulfur trioxide, the sulfite ion, and sulfur dioxide. Include any resonance structures.

   b. Compare the relative lengths of the sulfur-oxygen bonds in the three molecules.

3. Use the energies below to calculate the lattice energy of calcium chloride. In the table below, write an equation for each reaction step in the process and give the associated energy change. **Give the appropriate sign for the energy change.**

$CaCl_2$
Ca^{2+} $2Cl^-$

- X Bond energy for $Cl_2(g)$ = 242.6 kJ/mole
- X First electron affinity of Cl(g) = -348.7 kJ/mole
- X First ionization energy of Ca(g) = 590 kJ/mole
- X Second ionization energy of Ca(g) = 1145 kJ/mole
- X Enthalpy of sublimation of Ca(s) = 178.0 kJ/mole
- Enthalpy of reaction for the formation of calcium chloride = -795.0 kJ/mole

Reaction	Energy Change (kJ)
1. $Ca_{(s)} \rightarrow Ca_{(g)}$	+178.0 kJ/mol
2. $Ca_{(g)} \rightarrow Ca^+_{(g)} + e^-$	+590 kJ/mol
3. $Ca^+ \rightarrow Ca^{2+}_{(g)} + e^-$	+1145 kJ/mol
4. $Cl_{2(g)} \rightarrow 2Cl_{(g)}$	+242.6 kJ/mol
5. $2Cl_{(g)} + 2e^- \rightarrow 2Cl^-_{(g)}$	$(-348.7)2$ kJ/mol -697.4
6. $Ca^{2+}_{(g)} + 2Cl^-_{(g)} \rightarrow CaCl_{2(s)}$	−2253 kJ/mol
Overall reaction: $Ca_{(s)} + Cl_{2(g)} \rightarrow CaCl_{2(s)}$	−795.0 kJ/mol

↓ Scroll down
#1 & #2

4)

CO_3^{2-}

N $8 + 3(8) = 32$

A $4 + 3(6) + 2 = 24$

S $\longrightarrow 8$

U $\longrightarrow 16$

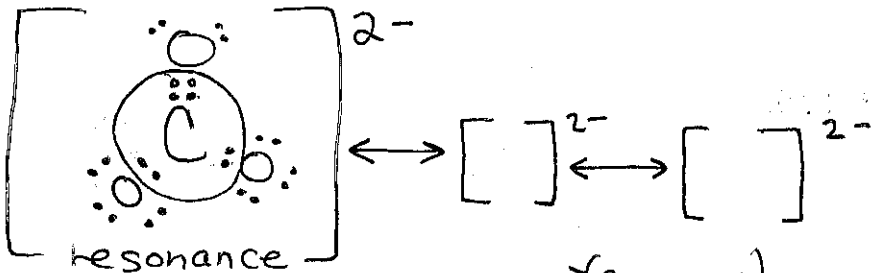
CO_2

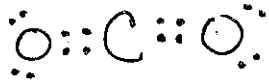
N $8 + 2(8) = 24$

A $4 + 2(6) = 16$

S $\longrightarrow 8$

U $\longrightarrow 8$





b) all bonds same (energy) (length) due to resonance

c) C=O bonds in CO_2 have more bond E (Stronger) than the bonds in CO_3^{2-}

← also shorter than the C-O bonds in CO_3^{2-}

* Bond order $= \frac{\#\text{ of bonds}}{\#\text{ of atoms}}$

CO_3^{2-} $\frac{4 \text{ bonds}}{3 \text{ atoms}}$

B.O. $= 1\frac{1}{3}$

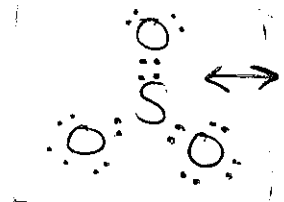
CO_2 $\frac{4 \text{ bonds}}{2 \text{ atoms}}$

B.O. $= 2$

The greater the B.O., the shorter + stronger the bonds

2. SO_3

N $8+3(8)=32$
A $6+3(6)=24$
S 8
U 16



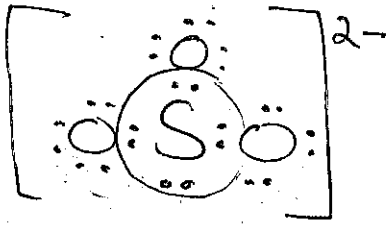
Resonance!

$B.O. = \frac{4}{3}$

$= 1\frac{1}{3}$

SO_3^{2-}

$8+3(8)=32$
$8+3(8)+2=26$
6
20



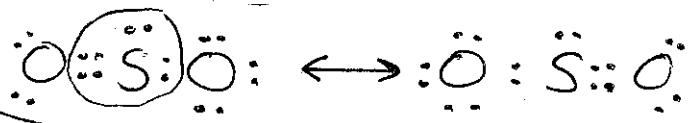
$B.O. = \frac{3}{3}$

$= 1$

Bonds are longest & weakest

SO_2

$8+2(8)=24$
$6+2(6)=18$
6
12



Resonance

$B.O. = \frac{3}{2}$

$= 1\frac{1}{2}$

Bonds are shortest & strongest

These bonds are the avg of 1 single & 1 double