Slide 1

More Lewis Structures

Lewis Dot Structures

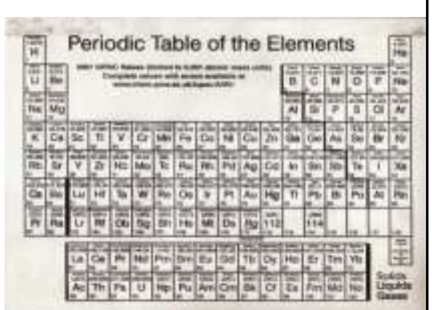
Slide 2

Total Number of Valence Electrons

The total number of available valence electrons is just the sum of the number of valence electrons that each atom possesses (ignoring d-orbital electrons)

Using SO_4^{2-} as an example, what is the total number of valence electrons?

Slide 3



Slide 4

Sulfur is a $3s^2 3p^4$ valence – 6 valence electrons
Oxygen is a $2s^2 2p^4$ valence – 6 valence electrons

SO_4^{2-}

S = 6 e^-
4 x O = 4 x 6 e^- = 24 e^-
2- = 2 extra electrons

Total valence electrons = 6 + 24 + 2 = 32 electrons

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Drawing Lewis Dot Structures

1. Determine the total number of valence electrons.
2. Determine which atom is the “central” atom.
3. Stick everything to the central atom using a single bond.

Slide 6

Central Atom

In a molecule, there are only 2 types of atoms:

1. “central” – bonded to more than one other atom.
2. “terminal” – bonded to only one other atom.

You can have more than one central atom in a molecule.

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Bonds

Bonds are pairs of shared electrons.

Each bond has 2 electrons in it.

You can have multiple bonds between the same 2 atoms. For example:

C-O

C=O

C ≡O

Each of the lines represents 1 bond with 2 electrons in it.

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Lewis Dot Structure

Each electron is represented by a dot in the structure

.
:Cl:
..

That symbol with the dots indicate a chlorine atom with 7 valence electrons.

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Dot structure for SO_4^{2-}

1. Total number of valence electrons:
   32 e-

2. Central Atom – typically, the central atom will be leftmost and/or bottommost in the periodic table. It is the atom that wants more than one thing stuck to it. H is NEVER the central atom.
   S is the better central atom
3. Stick all terminal atoms to the central atom using a single bond.

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Dot structure for SO_4^{2-}

```
      0
      |
O —  S — O
  |
  O
```

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Drawing Lewis Dot Structures

1. Determine the total number of valence electrons.
2. Determine which atom is the “central” atom.
3. Stick everything to the central atom using a single bond.
4. Fill the octet of every atom by adding dots.
5. Verify the total number of valence electrons in the structure.

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Dot structure for SO_4^{2-}

```
     ..
      : 0 :
  ..     |      ..
 :O —  S — O:
 ..     |       ..
      :O:
       ..
```

32 valence electrons in structure – looks good so far

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Drawing Lewis Dot Structures

1. Determine the total number of valence electrons.
2. Determine which atom is the “central” atom.
3. Stick everything to the central atom using a single bond.
4. Fill the octet of every atom by adding dots.
5. Verify the total number of valence electrons in the structure.
6. Add or subtract electrons to the structure by making/breaking bonds to get the correct # of valence electrons.
7. Check the “formal charge” of each atom.

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Formal Charge of an atom

“Formal charge” isn’t a real charge. It’s a pseudo-charge on a single atom.

Formal charge = number of valence electrons – number of bonds – number of non-bonding electrons.

Formal charge (FC) is ideally 0, acceptably +/-1, on occasion +/-2. The more 0s in a structure, the better.

The total of all the formal charges of each atom will always equal the charge on the entire structure (0 for neutral molecules).

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Dot structure for SO_4^{2-}

```
         ..
        : 0 :
   ..     |      ..
  :O —  S — O:
  ¨       |      ¨
         :O:
          ¨
```

FC(O) = 6 – 1 – 6 = -1
FC(S) = 6 – 4 – 0 = +2
Barely acceptable, but acceptable
Do we know something special about Sulfur?

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Exceptions to the Octet Rule

There are exceptions to the octet rule:

1. Incomplete octets – less than 8 electrons.
2. Expanded octets – more than 8 electrons

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Incomplete Octets

The most common elements that show incomplete octets are B, Be besides H.

So, for example, BCl_3 has the Lewis structure:

```
  ..       ..
: Cl – B – Cl:
  ¨    |    ¨
     : Cl :
        ¨
```

Total valence electrons is correct at 24.
FC (B) = 3 - 3 – 0 = 0
FC (Cl) = 7- 1 - 6 = 0

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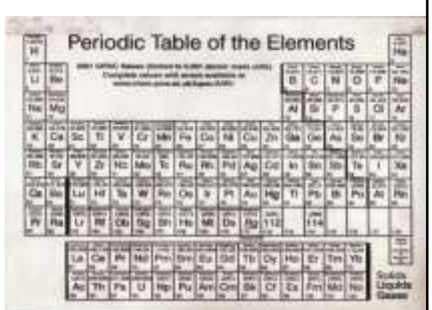

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Expanded Octets

The most common atoms to show expanded octets are P and S. It is also possible for some transition metals.

ANYTHING WITH ACCESS TO d-ORBITALS.

An example of an expanded octet would be PCl_5:

```
  ..   ..
 :Cl:  :Cl:
 ..   \  / ..
:Cl – P - Cl :
 ¨     |    ¨
     : Cl:
       ¨
```

Total valence e^- = 40

FC(P) = 5 – 5 – 0 =0

FC (Cl) = 7 – 1 – 6 = 0

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Couple extra bonds for Sulfur helps A LOT!

```
          : O1 :
   ..      ||     ..
  :O4 — S — O2 :
   ¨      ||      ¨
          :O3 :
```

Still 32 total electrons

FC(O_1, O_3) = 6 – 2 – 4 = 0

FC(O_2, O_4) = 6 – 1 – 6 = -1

FC(S) = 6 – 6 – 0 = 0

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Formal Charges are THE BEST! (For an ion, they must add up to the total charge, so you can't have all zeroes.)

And, even better than the formal charges…???

Slide 22

Resonance

Resonance is a difference in the orientation of the electrons. To truly be resonance, the formal charges of the new structure must be equivalent.

When you have resonance, the real structure is not any one of the individual structures but the combination of all of them.

You can always recognize resonance – there are double or triple bonds involved.

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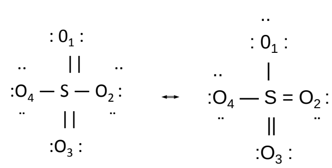
Couple extra bonds for Sulfur helps A LOT!



But those aren't the only two!

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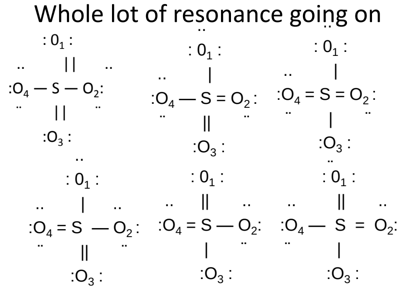
Whole lot of resonance going on



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Once you have a Lewis Structure, then you can determine the 3-D Molecular structure!