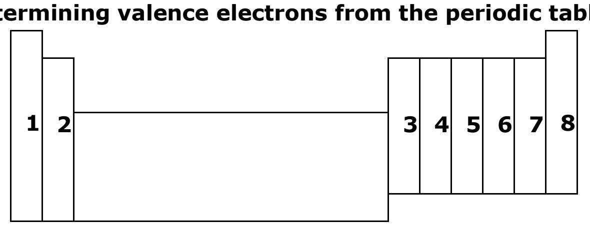
16: Drawing Molecules – Lewis Structures

Key Lewis Structure Terms

- **Valence Shell:** Electrons in the outermost shell that are involved in bonding.
- **Valence Bond Theory:** Overlap of atomic orbitals forming the bond.
- **Covalent Bond:** Bond formed between two nonmetals that involves shared electrons.
- **Octet Rule:** Atoms are most stable with a full valence shell (in most cases is "8").
- **Lewis Structure:** A 2D representation of a molecule and its bonds.
- **Lone Pair:** Pair of electrons not being shared in a bond.
- **Bonding Pair:** A pair of electrons is to form a bond. Both atoms sharing the electrons can "count" them in their valence shell.
- **Single bond:** One pair of shared electrons.
- **Double bond:** Two pairs of shared electrons. Shorter and stronger than a single bond.
- **Triple bond:** Three pairs of shared electrons. Shorter and stronger than a double bond.
- **Polyatomic Ion:** Group of atoms covalently bonded together that have a net charge.
- **Ionic Compound:** Electrons are transferred from one atom to another. Transfer of electrons results in net charges, which bond with electrostatic attraction.

Determining # of Valence Electrons

Determining valence electrons from the periodic table:



Note: Valence electrons in transition metals are not as reliable and predictable as the ones in main group elements.

Drawing Lewis Structures for an Element

1. Use the element symbol to represent the nucleus and core electrons.
2. Determine # of valence electrons.
3. Draw valence electrons—placing one on each side before doubling up.

HONC Valence Rule Mnemonic: The electrons needed for full valence shell and covalent bonds formed are H(1), O(2), N(3) and C(4) = *HONC*.

Exceptions to the Octet Rule

1. Hydrogen and Helium can only hold 2 electrons (they only have a 1s orbital).
2. Boron and Beryllium can be full with 6 electrons.
3. Any element in period 3 or below can have more than 8 electrons (they have empty d orbitals that can hold them).

Octet Exception Mnemonic: H&He: 2(full valence); Be: 4; B = 6; S&P > 8 = "*2 Hawks and Hens (2-legs); 4 Bears (4-legs); 6 Bugs (6-legs); many SPiders (<8 legs).*"

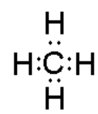
Note: Elements in period 3 and below have empty "d" orbitals that can be used to hold more than 8 valence electrons (18 Electrons Rule). Free radicals with one unpaired electron clearly do not follow the Octet rule.

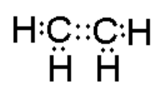
Arranging Atoms in Lewis Structures

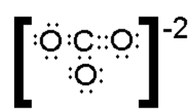
1. For molecules with only 2 elements, arrange the atoms symmetrically.
2. "COOH" is a carboxylic acid (both O's bond to the C and the H goes on one of the O's).
3. Hydrogen and halogens cannot go in the middle.
4. Write the remaining atoms in the order they appear in the formula.
5. Write the hydrogen and halogen atoms around the element they are written next to in the formula.

Drawing Covalent Lewis Structures

1. Arrange the atoms as above.
2. Determine the # of valence electrons for each atom.
3. Draw the valence electrons—do not double up where a bond is going to form between two atoms.
4. Count to see if all atoms have full valences (notice the exceptions).
5. If two atoms adjacent to each other do not have full valences, move in an electron from each to form a double bond. Repeat for triple bond if necessary.
6. If two atoms that are not adjacent to each other need to double bond, try moving a hydrogen to one of them to cause two atoms adjacent to each other to need the double bond.

Single bonds: 

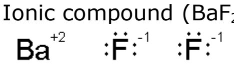
Double bonds: 

Polyatomic anion: 

Drawing Ionic Lewis Structures

Transfer the electrons from the metal to the nonmetals until all have full valences and the net charge = 0

Ionic compound (BaF_2): Ba^{+2} $2F^{-1}$



Another Approach to Lewis Structures

1. Arrange the atoms as above.
2. Determine the total # of valence electrons for the whole molecule.
3. Put one bonding pair between each set of atoms to be bonded.
4. Place remaining electrons in lone pairs, starting with the most electronegative element.
5. If atoms do not have full valence shells, move a lone pair from an adjacent atom in to double, or triple, bond.

How to Use This Cheat Sheet: These are the keys related to this topic. Try to read through it carefully twice then write it out on a blank sheet of paper. Review it again before the exams.

