Lewis Structures and Polarity

Formulas & Theorems Covered Today:
- Lewis Structure

Homework:

Notes:

Lewis Structures

- As we mentioned yesterday, Lewis structures are used to help determine how molecules are put together
- They can also be used to help us determine whether a molecule is polar, or non-polar
- The polarity of molecules, as you will see in the next few classes, will play a large role on the intermolecular forces that are so important for determining the physical properties that compounds possess

Lewis Structure Calculations

Step 1
- Place the least electronegative element at the center of the Lewis structure
- Write the symbols for the other atoms around the central atom
- Always place hydrogen and fluorine at end positions

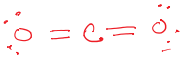
Step 2
- Determine the total number of valence electrons present in the molecule or ion
- Be sure to account for charges on any ions
  - If a cation, remove that number of valence electrons
  - If an anion, add that number of valence electrons

Step 3
- Determine the total number of valence electrons needed to complete all atoms octets and duets

Step 4
- Subtract the total number of valence electrons that exist in the atom or ion from the total number that you require to complete the octet (Step 3 - Step 2)
- Take that number and divide by 2 in order to determine the number of bonds (this is done because bonds are created by 2 electrons)

Step 5
- Subtract the number of shared electrons (bonding electrons) from the number of valence electrons (Step 2) to determine the number of non-bonding electron pairs (lone pairs)

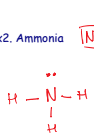
Step 6
- Place non-bonding pairs on outer atoms to fill their octets
- Any extra electrons are to be placed on the central atoms



Ex1. Carbon Monoxide

① $4ve^- + 6ve^- = 10ve^-$
② $8e^- + 8e^- = 16e^-$
③ $16e^- - 10ve^- = \frac{6e^-}{2} = 3$ bonds
④ $10ve^- - 6e^- = 4e^-$ (lone pairs)

Ex2. Ammonia NH_3

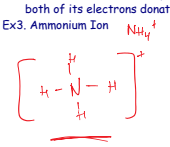


① $5ve^- + 3(1ve^-) = 8ve^-$
② $8e^- + 3(2e^-) = 14e^-$
③ $14e^- - 8ve^- = \frac{6e^-}{2} = 3$ bonds
④ $8ve^- - 6e^- = 2e^-$ (lone pairs)

Co-ordinate Covalent Compounds

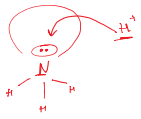
- Co-ordinate covalent compounds exist when a covalent bond that is found in a molecule has both of its electrons donated by one atom

Ex3. Ammonium Ion NH_4^+



① $5ve^- + 4(1ve^-) - 1ve^- = 8ve^-$
② $8e^- + 4(2e^-) = 16e^-$
③ $16e^- - 8e^- = \frac{8e^-}{2} = 4$ bonds
④ $8e^- - 8e^- = 0e^-$

because it is an ion

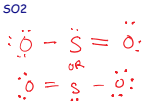


Ex4. Hydronium Ion H_3O^+

Resonance Structures

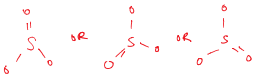
- These are compounds in which there is more than one Lewis structure possible
- When we measure these structures in a lab we do not see all of the possible structures but rather we see an average of all the bonds present

Ex5. SO2



① $6ve^- + 2(6ve^-) = 18e^-$
② $8e^- + 2(8e^-) = 24e^-$
③ $24e^- - 18e^- = \frac{6e^-}{2} = 3$ bonds
④ $18e^- - 6e^- = 12e^-$

Ex5. SO3



Expanded Octet

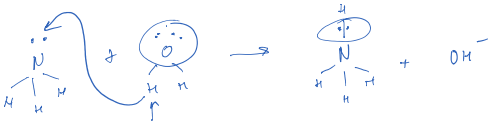
- As we move up the periodic table, we add more and more energy levels and subsequently we add more orbitals
- Larger atoms have access to these orbitals and are able to add more than an octet full of electrons
- To create the Lewis structures for these elements, you follow a different set of rules show below
- If you try and use the other rules, you will not produce enough bonds for the elements involved

Step 1
- Place the least electronegative element in the middle and place all other elements around them with single bonds

Step 2

$6ve^- + 4(6ve^-) = 30e^- + 2e^- = 32e^-$
$8e^- + 4(8e^-) = 40e^-$
$40e^- - 32e^- = \frac{8e}{2} = 4$ bonds
$32e^- - 8e^- = 24e^-$

$4e^- + 6e^- + 2(1e^-) = 12e^-$
$8e^- + 8e^- + 2(2e^-) = 20e^-$
$20e^- - 12e^- = \frac{8e^-}{2} = 4$ bonds
$12e^- - 8e^- = 4e^-$



- Determine the number of valence electrons present in the atoms involved
- Make sure to account for the charges on ions as with the other rules

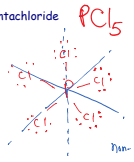
Step 3

- Determine the number of non-bonding pairs but subtracting the number of bonding electrons (2xnumber of single bonds) from the number of valence electrons

Step 4

- Place the non-bonding electrons on the outer atoms first and any extras onto the central atom

Ex6. Phosphorus pentachloride PCl_5



① $5e^- + 5(7e^-) = 40e^-$

② $8e^- + 5(8e^-) = 48e^-$

③ $48e^- - 40e^- = \frac{8e}{2} = 4$ bonds

$40e^- - 10e^- = 30e^-$

Non-polar molecule because it is symmetrical

Ex7. IF_4^-

① $7e^- + 4(7e^-) - 1e^- = 34e^-$

② $8e^- + 4(8e^-) = 40e^-$

③ $40 - 34 = \frac{6e}{2} = 3$ bond

$34e^- - 8e^- = 26e^-$