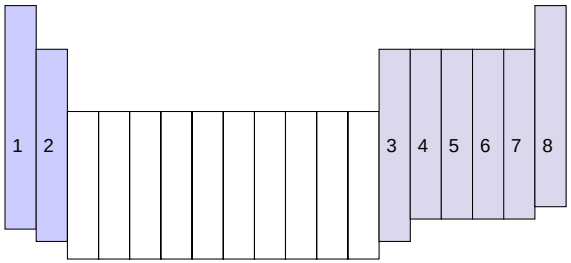
Drawing Molecules on Paper

- Lewis Structures (or Dot Structures) are one way we draw molecules on paper
- Since paper is 2-D and molecules aren't, it's not a perfect way to represent how molecules bond…but it's a good way to begin to visualize molecules

Drawing Ionic Compounds

1: How many valence electrons are in an atom?

The main groups of the periodic table each have 1 more valence electron than the group before it.



2: Placing electrons around an atom

- When atoms bond, they have 4 orbitals available (1 "s" and 3 "p"s). There are 4 places to put electrons
- Put one in each spot before doubling up!

Example: Draw the Lewis Structure for an oxygen atom

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Example: Draw the Lewis Structure for an oxygen atom

Oxygen is in the 6th main group.

There are 6 valence electrons.

3: Transfer electrons in ionic bonding

- Transfer electrons from metal atoms to non-metal atoms, keeping track of their new charge

Example: Draw the Lewis Structure for KCl

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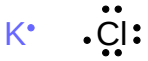

Potassium has 1 electron

Chlorine has 7 electrons

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Example: Draw the Lewis Structure for KCl

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4: Add more atoms if needed

- If the transfer from one atom to another doesn't result in full outer shells, add more atoms

Example: Draw the Lewis Structure the ionic compound of Barium fluoride

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Example: Draw the Lewis Structure the ionic compound of Barium fluoride

Barium has 2 electron
Fluorine has 7 electrons

The fluorine is full, but the Barium isn't!

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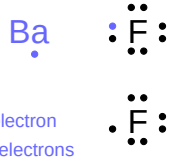
Example: Draw the Lewis Structure the ionic compound of Barium fluoride



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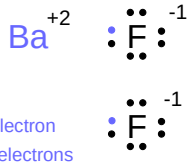

Barium has 2 electron
Fluorine has 7 electrons

Now all have full valence shells and the charges are balanced, just as when you learned to write in Chpt 2—BaF_2!

A note about Ionic Dot Structures

- The atoms are not sharing the electrons—make sure you clearly draw the atoms separate!

Drawing Covalent Compounds

Tips for arranging atoms

- Hydrogen & Halogens (F, Cl, Br, I) can only bond with one other atom—they can't go in the middle of a molecules
  - Always put them around the outside
- In general, write out the atoms in the same order as they appear in the chemical formula

Formal Charge

Start the process by drawing possible Lewis Structures.

1. Choose the central atom. Usually the least electronegative.
2. Count total valence electrons for the molecule.
3. Start by placing one pair of electrons for each bond.
4. Satisfy the octet rule. This may require making double or triple bonds (and removing lone pairs)
5. If you can draw multiple structures, check the formal charge. See below.

Repeat first two steps from before

1. Use the periodic table to decide how many electrons are around each atom
2. Write the electrons around each atom

Example: Draw the Lewis Structure for CH_4

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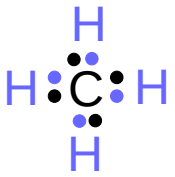
Example: Draw the Lewis Structure for CH_4

Carbon has 4 electrons

Each hydrogen has 1



Remember, "H" can't go in the middle…put them around the Carbon!

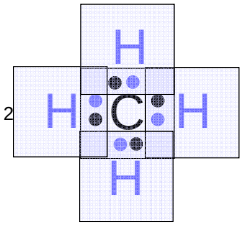
3: Count electrons around each atom

- Any electron that is being shared (between two atoms) gets to be counted by both atoms!
- All atoms are full with 8 valence electrons (except H—can only hold 2)

Example: Draw the Lewis Structure for CH_4

Carbon has 8

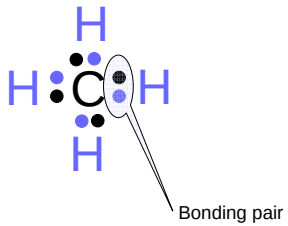
Each Hydrogen has 2



All have full valence shells—drawing is correct!

Bonding Pair

- Pair of electrons shared by two atoms…they form the "bond"



What if they're not all full after that?

- Sometimes, the first 3 steps don't leave you with full valence shells for all atoms

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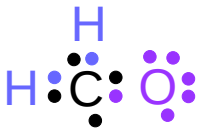

Remember that hydrogen atoms can't go in the middle!

What if they're not all full after that?

- Sometimes, the first 3 steps don't leave you with full valence shells for all atoms

The two hydrogen atoms are full

But the carbon and oxygen only have 7 each!

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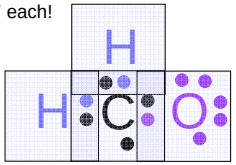

What if they're not all full after that?

- Sometimes, the first 3 steps don't leave you with full valence shells for all atoms

But they each have a single, unshared electron.

They could share those with each other!

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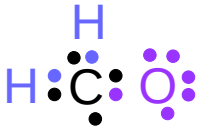

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- Sometimes, the first 3 steps don't leave you with full valence shells for all atoms

Now the carbon and oxygen both have a full valence!

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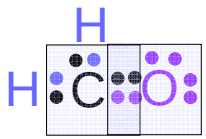
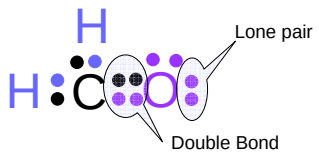


Double Bonds & Lone Pairs

- Double bonds are when 2 pairs of electrons are shared between the same two atoms
- Lone pairs are a pair of electrons not shared—only one atom "counts" them



And when a double bond isn't enough…

- Sometimes forming a double bond still isn't enough to have all the valence shells full

Example: Draw the Lewis Structure for C_2H_2

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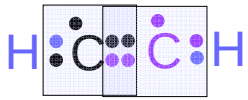
Each carbon atom only has 7 electrons…not full

Example: Draw the Lewis Structure for C_2H_2



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But they each have an un-paired electron left!

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And when a double bond isn't enough…

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Now they each have 8 electrons!

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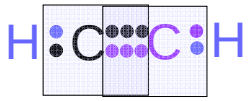

Triple Bonds

- A Triple Bond occurs when two atoms share 3 pairs of electrons

Properties of multiple bonds

Single Bond

Double Bond

Triple Bond

Shorter bonds (atoms closer together)

Stronger bonds (takes more energy to break)

Polyatomic Ions

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- They are a group of atoms bonded together that have an overall charge

Example: Draw the Lewis Structure for CO_3^{-2}

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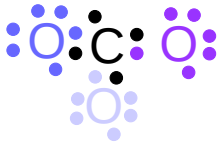


When there's a single atom of one element, put it in the middle

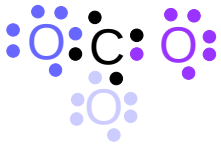
Polyatomic Ions

- They are a group of atoms bonded together that have an overall charge

None of the atoms have full valence shells…they all have 7!

The carbon can double bond with one of the oxygen atoms

Example: Draw the Lewis Structure for CO_3^{-2}



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Now the Carbon and the one oxygen have 8…but the other two oxygen atoms still only have 7

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This is a polyatomic ion with a charge of "-2"…that means we get to "add" 2 electrons!

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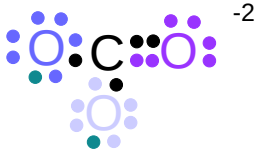

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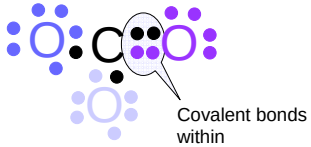
Covalent bond within…ionic bond between

- Polyatomic ions have a covalent bond within themselves…
- But an ionic bond with other ions

Na •

Na •



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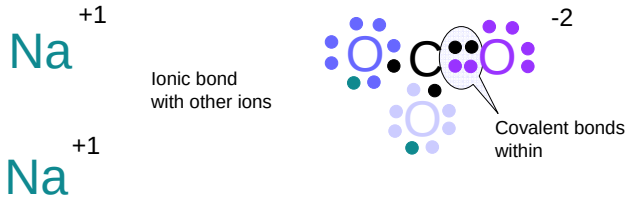


Isomers

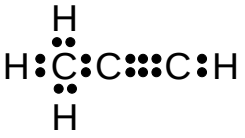
More than one possibility

- Often, there's more than one way to correctly draw a Dot Structure

Chemical Formula: C_3H_4

Contains 2 sets of double bonds between carbons

Both structures have full valence shells!

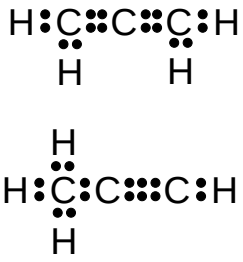


Chemical Formula: C_3H_4

Contains 1 triple bond and 1 single bond between carbons

Both are "correct"

- The chemical formula alone does not give you enough information to differentiate between the two structures



Chemical Formula: C_3H_4

You'll learn in Chapter 11 how to differentiate between these two structures with chemical names

Isomers

- Isomers: Structures with the same chemical formula but different chemical structure
- Atoms must be bonded differently (multiple versus single bonds) or in a different order) but have the same overall chemical formula to be isomeric structures