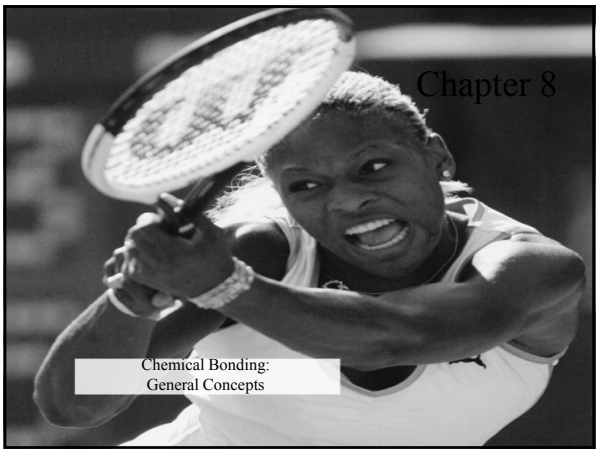
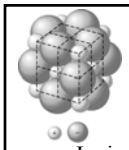




8.1 Electron transfer leads to the formation of ionic compounds

- Ionic compounds form when metals and nonmetals react
- The attraction between positive and negative ions is called an **ionic bond**
- But why do metals form cations and nonmetals form anions?
  - Energy Trends (ionization energy and electron affinity)
  - Stability of noble gas electron configuration

2

Ions and the Noble Gas

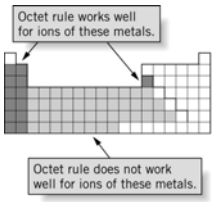
- Let's look at sodium
  - Na $1s^2 2s^2 2p^6 3s^1$
- If we remove one electron, where does it come from?
  - Na^+ $1s^2 2s^2 2p^6$
- Now, sodium ion has the same electronic configuration as Ne, a noble gas. It is very stable.
- So, why doesn't Na^{2+} form?

3

Noble Gases and the Octet Rule

- All noble gases (except He) have 8 valence electrons
- This is called an octet of electrons
- Octet Rule – atoms tend to gain or lose electrons until they have achieved an outer shell that contains 8 electrons.
- How many valence electrons does Na^+ have?

4



Using the Octet Rule

- We can use the octet rule to predict ions for the IA, IIA and IIIA metals.
- It doesn't work well for transition metals.
- For these cations:
  - Electrons are removed from the shell with the largest value of *n* first.
  - Within a given shell, electrons are removed from the orbitals with the highest value of *l*.
    - f before d before p before s

5

Electron Configurations of Ions

1. Write the correct notation for the atom
2. For anions: add electrons until you have equaled the negative charge, fill according to Hund's Rule
3. For cations: remove electrons from the electron shell of the highest n
   - If there is a choice of a subshell within the *n*th subshell, the electron or electrons are removed from the maximum *l*

6

What is the electron configuration of:

Sb^{3+}

V^{3+}

Cr^{2+}

Cr^{3+}

Cr^{6+}

7

8.2 Lewis Symbols

- Convenient representations of valence electrons
- Consists of the chemical symbol for the element plus a dot for each valence electron.
- Element symbol represents the nucleus.
- In normal circumstances, 2 electrons per side, 4 sides.
- If all sides are full, 8 electrons are in the valence shell…this is called an octet

8

Sulfur

Nobel gas configuration is $[Ne]3s^23p^4$, thus there are six valence electrons. Its Lewis symbol would therefore be:

Remember: want the highest number of unpaired electrons, refer to noble gas configuration.

9

Give the number of valence electrons for the following and draw the Lewis Dot structure.

Ca

Se

Al

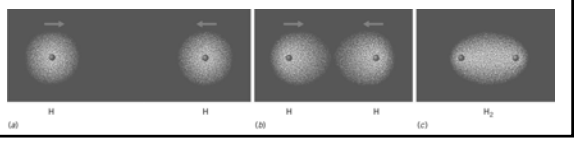
C

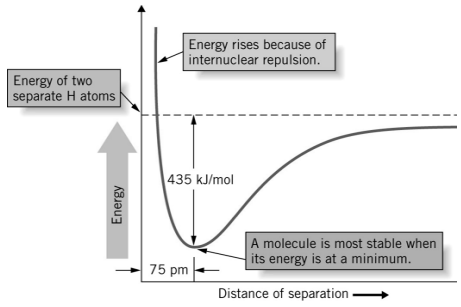
As

10

8.3 Covalent Bonds

- Electrons and nuclei are continually moving.
- But, in the motion, they arrange themselves in ways that optimize the net attractive forces among the electrons and the nuclei.
- Balance is achieved when the electrons are concentrated between the nuclei.
- Covalent bond - a net force of attraction produced by the sharing of a pair of electrons.





- Covalent bonds are characterized by:
  - **bond distance –** average distance between the nuclei
  - **bond energy –** energy released when the bond forms

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The Covalent Bond

- Lewis symbols can be used to represent the covalent or electron pair bond

$$H\bullet + \bullet H \rightarrow H:H$$

- Both atoms have 2 electrons.
- For simplicity, electron pair bonds are usually represented by a dash

H - H

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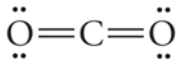
Bonding and the Octet Rule

- When atoms form covalent bonds, they tend to share electrons to achieve an octet.
- One shared pair of electrons is called a single bond
- Double and triple bonds are also common:



:N≡N:

14

TABLE 8.3 Average Bond Lengths and Bond Energies Measured for Carbon–Carbon Bonds

Bond	Bond Length (pm)	Bond Energy (kJ/mol)
C—C	154	348
C=C	134	615
C≡C	120	812

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Exceptions to the Octet Rule

- H and He follow the duet rule
- B usually has only 6 surrounding electrons
- Be bonds with just 4 surrounding electrons
- Elements in the 3rd period and higher contain "d" orbitals, so they may accommodate more than 8.
  - The result is an "expanded octet"

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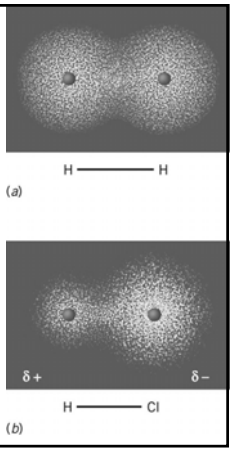
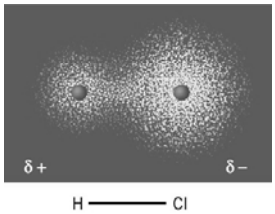
8.4 Covalent bonds can have partial charges



- When a bond is formed between identical atoms, each atom has an equal share of the electrons.
- But, when different kinds of atoms combine (HCl), one nucleus usually attracts the electrons in the bond more strongly than the other.

- **Nonpolar bond** – a bond between two atoms that has an equal sharing of electrons.

- **Polar bond** – a bond between two atoms where the sharing is unequal.
  - The electrons are closer to one atom than the other.
  - The atoms develop **partial charges**, δ.
  - Let's look again at HCl



How do you determine which atom has the partial negative charge and which atom has the partial positive charge?

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Electronegativity is the answer!

- Electronegativity – the extent to which an element attracts bonding electrons.
- Denoted by the Greek symbol chi, χ
- When two atoms have different electronegativities, the bond between them is polar.
- The bigger the difference in electronegativities, the more polar the bond is.

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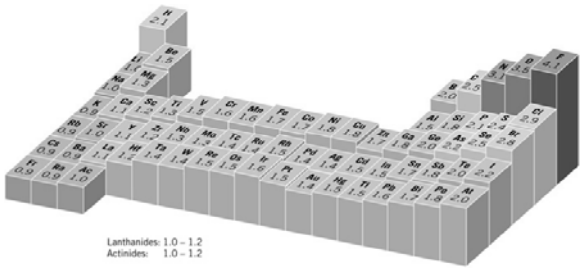

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Polar Bonds

- From graph, you can see that nonmetals are more electronegative than metals.
- The atom that has the largest electronegativity carries the partial negative charge.
- In general: the further apart the atoms are on the periodic table, the larger the difference in electronegativity.
- And, the larger the difference in electronegativity, the more polar the bond.

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Practice Problem

- Choose the atom that carries the partial negative charge:
  1. P – Br
  2. Si – Cl
  3. S – Cl

Skipping 8.5

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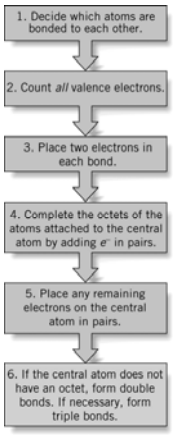

•8.6 Drawing Lewis Structures

I usually choose to flip these two steps.

1. Counting Valence Electrons
   - Use the periodic table for reference
   - Add an electron for each indicated negative charge, subtract an electron for each indicated positive charge.
2. Decide which atoms are bonded to each other.
   - If a central atom has various groups bonded to it, it is usually listed first: CO_3^{2-}, SF_4
   - Often atoms are written in the order of their connections: HCN

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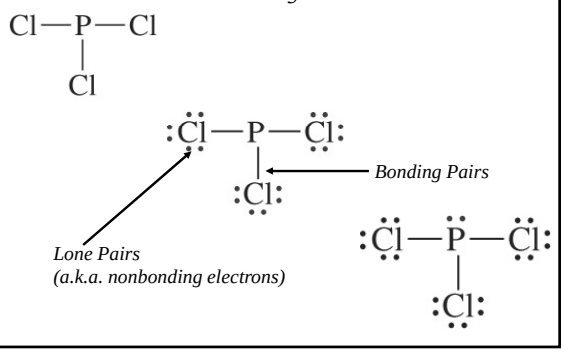
5+(3*7)=26 e^-

PCl_3



Practice Problems

NH_4^+	OF_2
IF_4^-	SCN^-
SO_4^{2-}	NO_2^+
ClF_3	SF_6

We are NOT covering the section on Formal Charge. You are NOT responsible for it.

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8.7 Resonance Structures.

- Some molecules and ions are not well represented by a single Lewis structure
- Consider the case of the formate ion, CHO_2^-
- Let's draw the Lewis Structure

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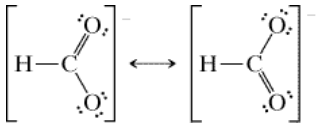

- Both of these structures are correct.
- They are referred to as resonance structures or contributing structures.
- The actual structure is a hybrid of both of them.

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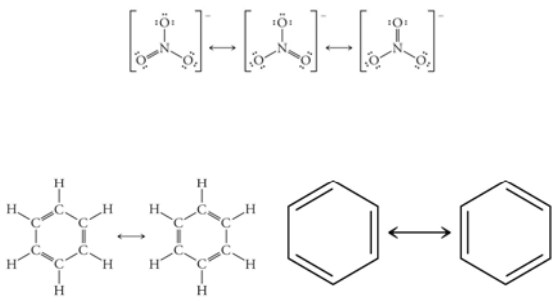

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Hints on Lewis Dot Structures

1. Octet rule is the most useful guideline.
2. Carbon forms 4 bonds.
3. Hydrogen typically forms <u>one</u> bond to other atoms.
4. When multiple bonds are forming, they are usually between C, N, O or S.
5. Nonmetals can form single, double and triple bonds, but not quadruple bonds.
6. The central atom can have more than an octet if it is in the 3rd period or higher.
7. **Always account for single bonds and lone pairs before forming multiple bonds.**

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