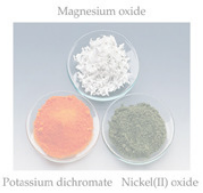
Today's Lecture

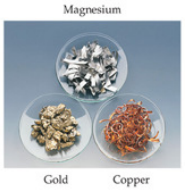
- ✓Announcements
- ✓Basic Concepts of Chemical Bonding
- ✓Quizzes

Announcements

- Office hours
  - Mon, Wed, 11:30-12:30 am
  - Sun,Tue,Thu 11:30-12:30 pm
- Office Location
  - D1-L0
- Reading
  - Chapter 8, Sections (8.1),(8.2), (8.3) and (8.4)
- Suggested Problems
  7,11,15,17,19,2123,25,29,33,35,39,41

Chemical Bonds





- Three basic types of bonds
  - Ionic
    - Electrostatic attraction between ions
  - Covalent
    - Sharing of electrons
  - Metallic
    - Metal atoms bonded to several other atoms

Matter And Measurement

Ionic Bonding

Matter And Measurement

Energetics of Ionic Bonding

Example NaCl

TABLE 7.2 Successive V

Element	I_1
Na	495
Mg	738
Al	578

It takes 495 kJ/mol to remove electrons from sodium.

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Energetics of Ionic Bonding

We get 349 kJ/mol back by giving electrons to chlorine.

O −141	F −328	Ne > 0
S −200	**Cl −349**	Ar > 0
Se −195	Br −325	Kr > 0
Te	I −295	Xe

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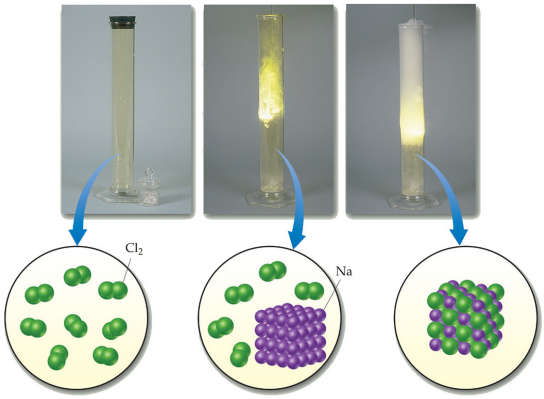
Energetics of Ionic Bonding



But these numbers don't explain why the reaction of sodium metal and chlorine gas to form sodium chloride is so exothermic!

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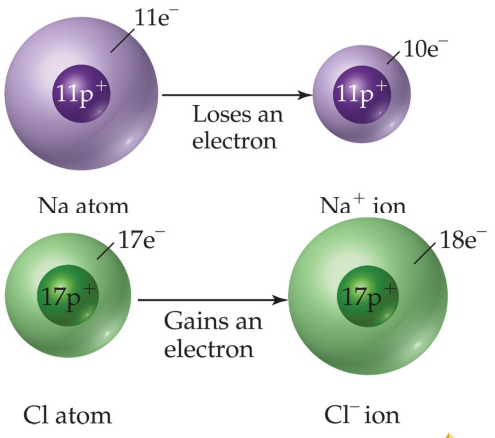
Energetics of Ionic Bonding

- There must be a third piece to the puzzle.
- What is as yet unaccounted for is the electrostatic attraction between the newly-formed sodium cation and chloride anion.



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Lattice Energy

- This third piece of the puzzle is the lattice energy:
  - *The energy required to completely separate a mole of a solid ionic compound into its gaseous ions.*
- The energy associated with electrostatic interactions is governed by Coulomb's law:

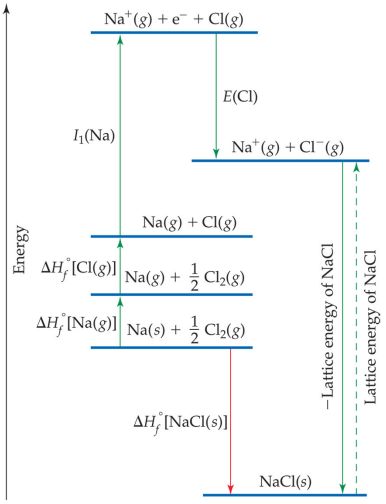
$$E_{el} = \kappa \frac{Q_1 Q_2}{d}$$

Lattice Energy

- Lattice energy, then, increases with the charge on the ions.
- It also increases with decreasing size of ions.

Compound	Lattice Energy (kJ/mol)	Compound	Lattice Energy (kJ/mol)
LiF	1030	$MgCl_2$	2326
LiCl	834	$SrCl_2$	2127
LiI	730		
NaF	910	MgO	3795
NaCl	788	CaO	3414
NaBr	732	SrO	3217
NaI	682		
KF	808	ScN	7547
KCl	701		
KBr	671		
CsCl	657		
CsI	600		

Energetics of Ionic Bonding



By accounting for all three energies (ionization energy, electron affinity, and lattice energy), we can get a good idea of the energetics involved in such a process.

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Energetics of Ionic Bonding

- These phenomena also helps explain the "octet rule."

TABLE 7.2 Successive Values of Ionization E

Element	I_1	I_2	I_3
Na	495	4562	
Mg	738	1451	7733
Al	578	1817	2745
Si	786	1577	
P	1012	1907	

- Metals, for instance, tend to stop losing electrons once they attain a noble gas configuration because energy would be expended that cannot be overcome by lattice energies.

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Sample Exercise 8.2 Charges on Ions

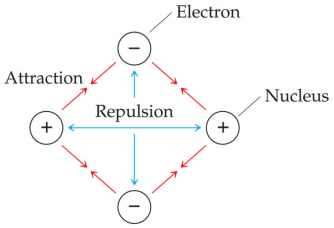
Predict the ion generally formed by **(a)** Sr, **(b)** S, **(c)** Al.

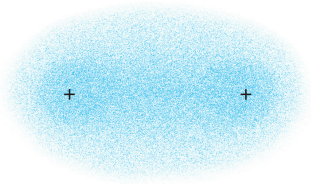
Practice Exercise

Predict the charges on the ions formed when magnesium reacts with nitrogen.

Covalent Bonding

Covalent Bonding





- In covalent bonds atoms share electrons.
- There are several electrostatic interactions in these bonds:
  - Attractions between electrons and nuclei
  - Repulsions between electrons
  - Repulsions between nuclei

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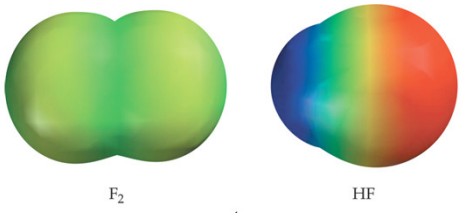
Polar Covalent Bonds



F_2 HF

- Though atoms often form compounds by sharing electrons, the electrons are not always shared equally.
- Fluorine pulls harder on the electrons it shares with hydrogen than hydrogen does.
- Therefore, the fluorine end of the molecule has more electron density than the hydrogen end.

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Lewis Structures

Lewis structures are representations of molecules showing all electrons, bonding and nonbonding.

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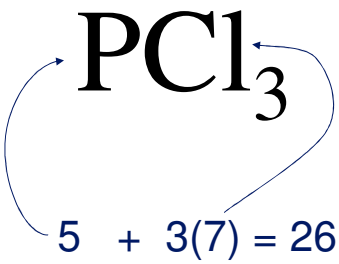
Writing Lewis Structures



1. Find the sum of valence electrons of all atoms in the polyatomic ion or molecule.
   - If it is an anion, add one electron for each negative charge.
   - If it is a cation, subtract one electron for each positive charge.

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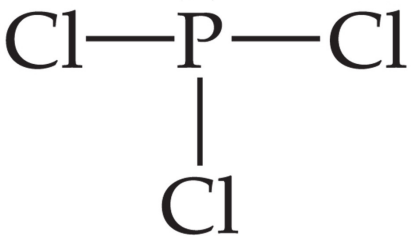
Writing Lewis Structures



2. The central atom is the *least* electronegative element that isn't hydrogen. Connect the outer atoms to it by single bonds.

Keep track of the electrons:

26 - 6 = 20

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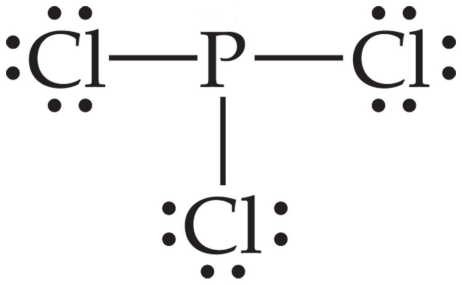
Writing Lewis Structures



3. Fill the octets of the outer atoms.

Keep track of the electrons:

26 - 6 = 20; 20 - 18 = 2

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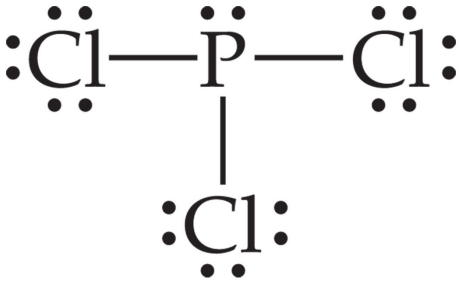
Writing Lewis Structures



4. Fill the octet of the central atom.

Keep track of the electrons:

26 - 6 = 20; 20 - 18 = 2; 2 - 2 = 0

Matter And Measurement

Writing Lewis Structures

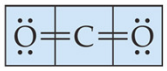
5. If you run out of electrons before the central atom has an octet…

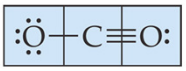
…form multiple bonds until it does.

Matter And Measurement

Writing Lewis Structures

- Then assign formal charges.
  - For each atom, count the electrons in lone pairs and half the electrons it shares with other atoms.
  - Subtract that from the number of valence electrons for that atom: the difference is its formal charge.





Valence electrons:	6	4	6	6	4	6
−(Electrons assigned to atom):	6	4	6	7	4	5
Formal charge:	0	0	0	−1	0	+1

Sample Exercise 8.3 Lewis Structure of a Compound

Given the Lewis symbols for the elements nitrogen and fluorine shown in Table 8.1, predict the formula of the stable binary compound (a compound composed of two elements) formed when nitrogen reacts with fluorine, and draw its Lewis structure.

Sample Exercise 8.3 Lewis Structure of a Compound

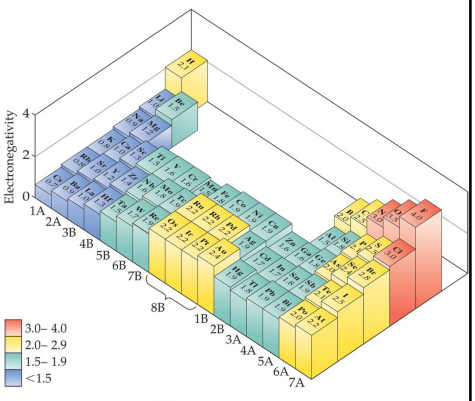
Practice Exercise

Compare the Lewis symbol for neon with the Lewis structure for methane, CH_4. In what important way are the electron arrangements about neon and carbon alike? In what important respect are they different?

Matter And Measurement

Electronegativity

- *Electronegativity is the ability of atoms in a molecule to attract electrons to themselves.*
- On the periodic chart, electronegativity increases as you go…
  - …from left to right across a row.
  - …from the bottom to the top of a column.



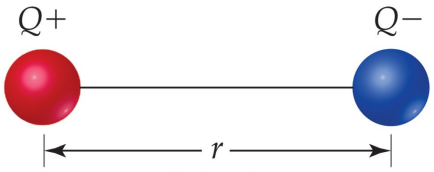
Matter And Measurement

Polar Covalent Bonds

- When two atoms share electrons unequally, a bond dipole results.
- The dipole moment, μ, produced by two equal but opposite charges separated by a distance, r, is calculated:

$$\mu = Qr$$

- It is measured in debyes (D).

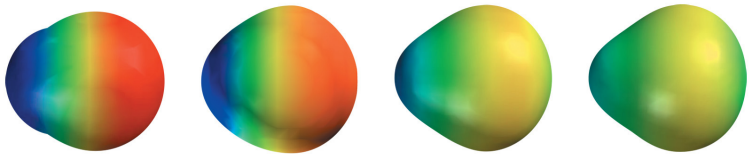


Matter And Measurement

Polar Covalent Bonds

Compound	Bond Length (Å)	Electronegativity Difference	Dipole Moment (D)
HF	0.92	1.9	1.82
HCl	1.27	0.9	1.08
HBr	1.41	0.7	0.82
HI	1.61	0.4	0.44

The greater the difference in electronegativity, the more polar is the bond.



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Sample Exercise 8.4 Bond Polarity

In each case, which bond is more polar: **(a)** B—Cl or C—Cl , **(b)** P—F or P—Cl? Indicate in each case which atom has the partial negative charge.

Practice Exercise

Which of the following bonds is most polar: S—Cl, S—Br, Se—Cl, or Se—Br?

Sample Exercise 8.5 Dipole Moments of Diatomic Molecules

The bond length in the HCl molecule is 1.27 Å. **(a)** Calculate the dipole moment, in debyes, that would result if the charges on the H and Cl atoms were 1+ and 1–, respectively. **(b)** The experimentally measured dipole moment of HCl(*g*) is 1.08 D. What magnitude of charge, in units of *e*, on the H and Cl atoms would lead to this dipole moment?

Practice Exercise

The dipole moment of chlorine monofluoride, ClF(*g*), is 0.88 D. The bond length of the molecule is 1.63 Å. **(a)** Which atom is expected to have the partial negative charge? **(b)** What is the charge on that atom, in units of *e*?

Quizzes

The two types of chemical bonds commonly found in compounds are:

a. doric and covalent.
b. ionic and electrolytic.
c. ionic and covalent.
d. electrolytic and compound.

The electrons used by atoms to form chemical bonds are the:

a. core electrons.
b. valence electrons.
c. lone pair electrons.
d. unpaired electrons.

"Atoms tend to gain, lose, or share electrons until they are surrounded by eight valence electrons" is a statement of:

a. the rule of octaves.
b. the double quartet rule.
c. the eight electron rule.
d. the octet rule.

When a transition metal atom becomes a +1 ion, the electron lost usually comes from what type of orbital?

a. *p*
b. *f*
c. *d*
d. *s*

A molecule of CS_2 contains:

a. two single bonds.
b. two double bonds.
c. one single bond and one double bond.
d. one single bond and one triple bond.

Which choice below correctly lists the elements in order of increasing electronegativity?

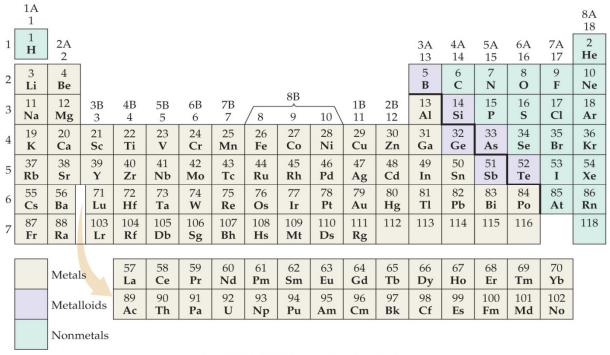
a. C < N < O < F
b. N < C < O < F
c. N < C < F < O
d. C < N < F < O

As the number of bonds between two atoms increases, the distance between the atoms:

a. increases.
b. decreases.
c. remains unchanged.
d. varies with the atoms involved.

How many unpaired electrons are there in Cu^+?

1. 0
2. 1
3. 2
4. 3
5. 4



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Next

- Chapter 10
  - Gases

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