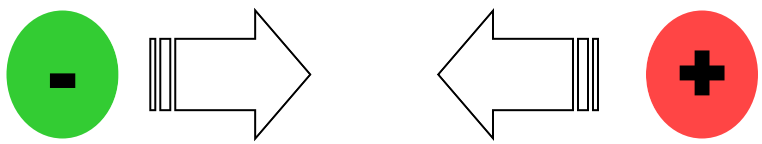
Chemical Bonding

Ionic Bond

Results from the transfer of one or more electrons from one atom to another.

Ionic Bonds



Electrostatic attractions between ions

Increase charge – remove an electron

Decrease charge – add an electron

Ions: atoms which have an electrical charge

- Cations - forms when a neutral atom loses one or more valence electrons
- Anions - forms when a neutral atom gains one or more valence electrons

Ionic Compounds

- Formed by ionic bonds
- Usually form between a metal and nonmetal
- Tend to form noble gas(octet) electron configurations
- Lattice energy - The energy required to separate exactly 1 mole of the solid into its component gaseous ions.

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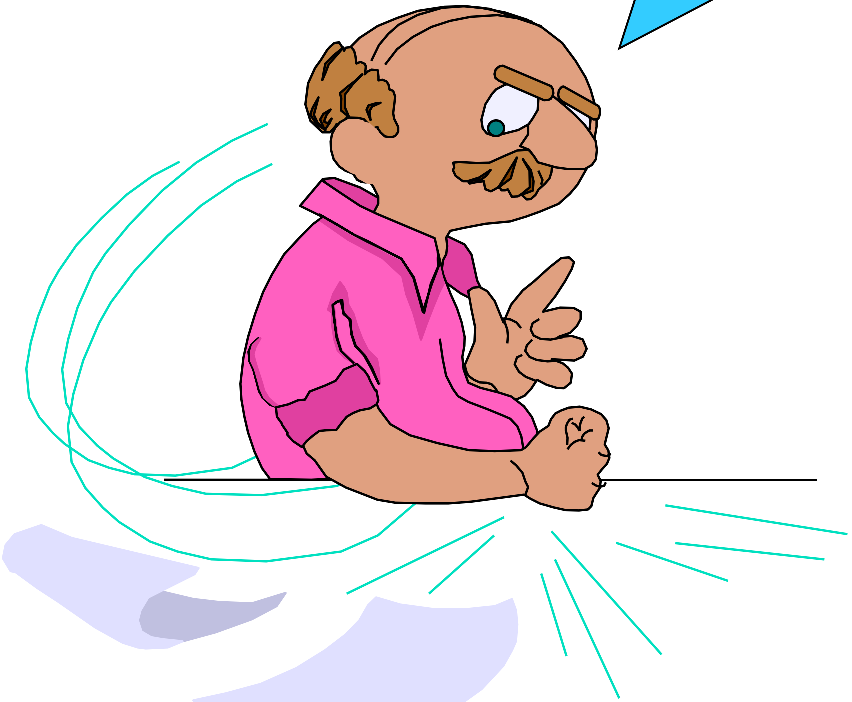
It is the loss, gain, or sharing of valence electrons that determines how elements react.



Ionization Energy

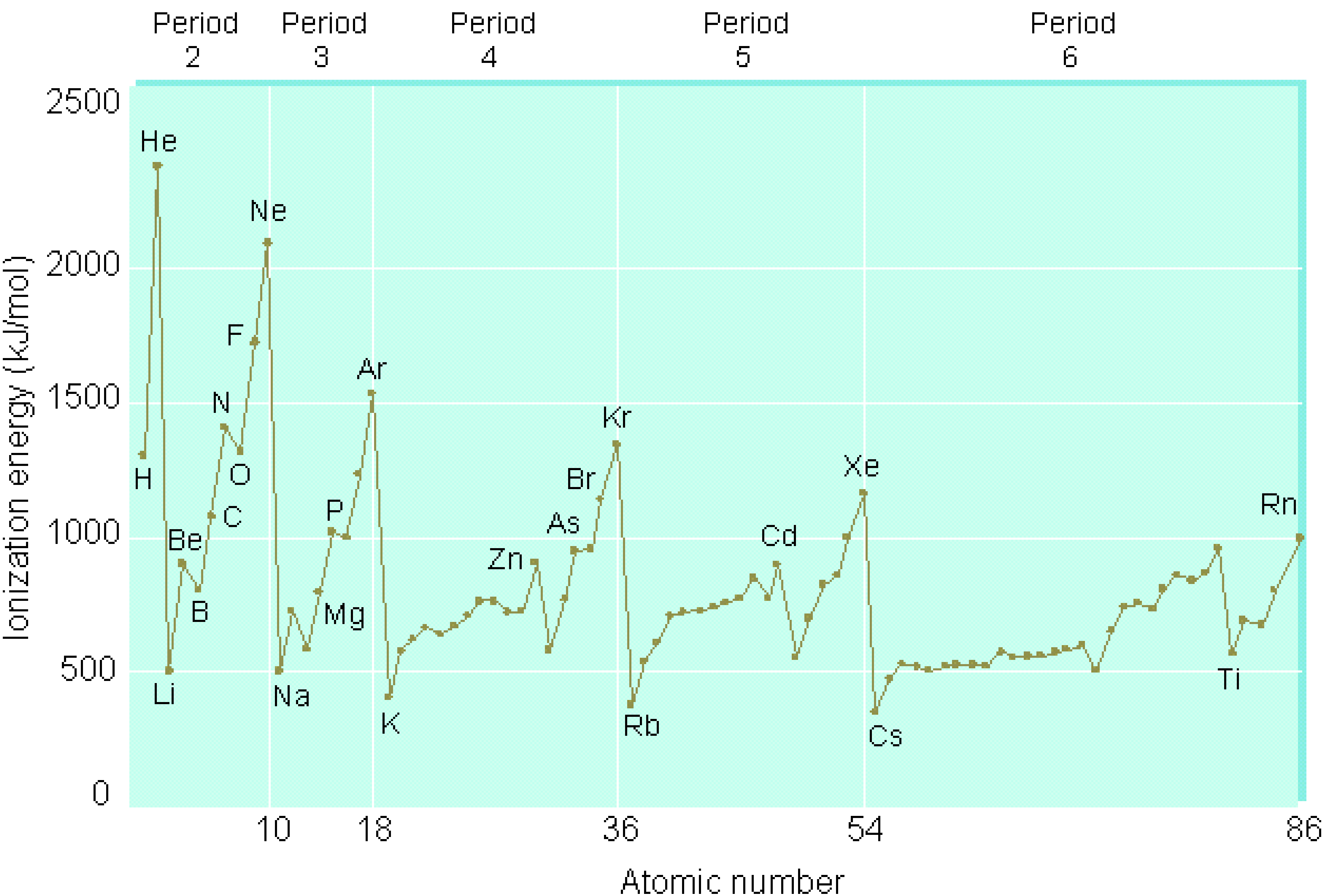
$$X + \text{energy} \rightarrow X^{+} + e^{-}$$

First Ionization Energies (KJ/mol)

Increases through a period

Decreases through a family

H 1310																	He 2370
Li 520	Be 900											B 800	C 1090	N 1400	O 1310	F 1680	Ne 2080
Na 490	Mg 730											Al 580	Si 780	P 1060	S 1000	Cl 1250	Ar 1520
K 420	Ca 590	Sc 630	Ti 660	V 650	Cr 660	Mn 710	Fe 760	Co 760	Ni 730	Cu 740	Zn 910	Ga 580	Ge 780	As 960	Se 950	Br 1140	Kr 1350
Rb 400	Sr 550	Y 620	Zr 660	Nb 670	Mo 680	Tc 700	Ru 710	Rh 720	Pd 800	Ag 730	Cd 870	In 560	Sn 700	Sb 830	Te 870	I 1010	Xe 1170
Cs 380	Ba 500	La 540	Hf 700	Ta 760	W 770	Re 760	Os 840	Ir 890	Pt 870	Au 890	Hg 1000	Tl 590	Pb 710	Bi 800	Po 810	At . . .	Rn 1030
Fr . . .	Ra 510																


Period 2
Period 3
Period 4
Period 5
Period 6
Ionization energy (kJ/mol)
2500
2000
1500
1000
500
0
He
Ne
F
Ar
N
H
O
C
Be
B
Li
Na
P
Mg
K
Kr
Br
As
Zn
Rb
Xe
Cd
Cs
Rn
Tl
10
18
36
54
86
Atomic number

ELECTRON CONFIGURATIONS AND IONIZATION ENERGIES OF SODIUM, MAGNESIUM, AND ALUMINUM

Elements	*Electron configuration*	*Ionization energy* (kcal/mole)			
		1st electron	*2nd electron*	*3nd electron*	*4th electron*
Na	$1s^22s^22p^63s^1$	119	1090	1652	2281
Mg	$1s^22s^22p^63s^2$	176	347	1848	2519
Al	$1s^22s^22p^63s^23p^1$	138	434	656	2767

Electron Affinity

$$X + e^- \rightarrow X^- + \text{energy}$$

Electron Affinities (KJ/mol)

1A							**8A**
H							**He**
−72	2A	3A	4A	5A	6A	7A	+20[a]
Li	**Be**	**B**	**C**	**N**	**O**	**f**	**Ne**
−60	+240[a]	−23	−123	0	−141	−322	+30
Na	**Mg**	**Al**	**Si**	**P**	**S**	**Cl**	**Ar**
−53	+230[a]	−44	−120	−74	−201	−348	+35[a]
K	**Ca**	**Ga**	**Ge**	**As**	**Se**	**Br**	**Kr**
−48	+150[a]	−40[a]	−116	−77	−195	−324	+40[a]
Rb	**Sr**	**In**	**Sn**	**Sb**	**Te**	**I**	**Xe**
−46	+160[a]	−40[a]	−121	−101	−190	−295	+40[a]
Cs	**Ba**	**Tl**	**Pb**	**Bi**	**Po**	**At**	**Rn**
−45	+ 50[a]	−50	−101	−101	−170[a]	−270[a]	+40[a]

[a] Calculated value.

$$Na + 490\ KJ/mol \rightarrow Na^{+} + e^{-}$$

$$Cl + e^{-} \rightarrow Cl^{-} + 348\ KJ/mol$$

$$Na^{+} + Cl^{-} \rightarrow NaCl + 769\ KJ/mol$$

$$Na + Cl \rightarrow NaCl + 627\ KJ/mol$$

Electron Configurations of Ions
&
Lewis Structures of Ionic Compounds

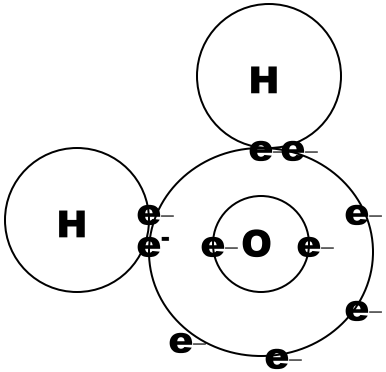
Covalent Bonds

A bond resulting from the sharing of electrons (usually two).

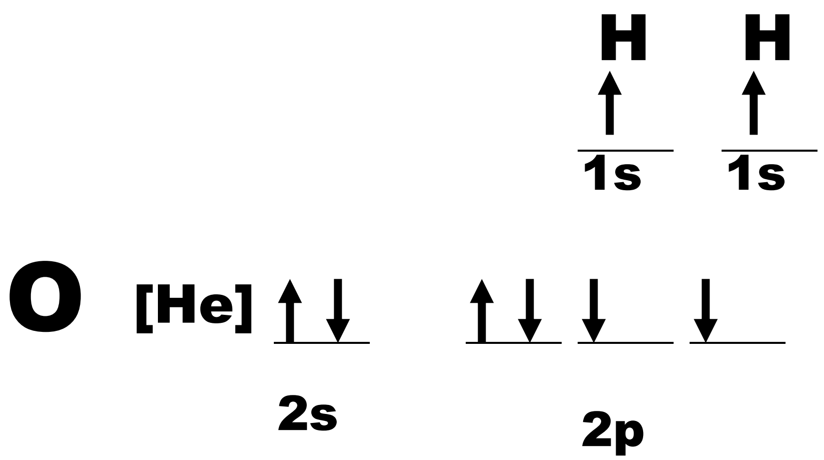
Molecule

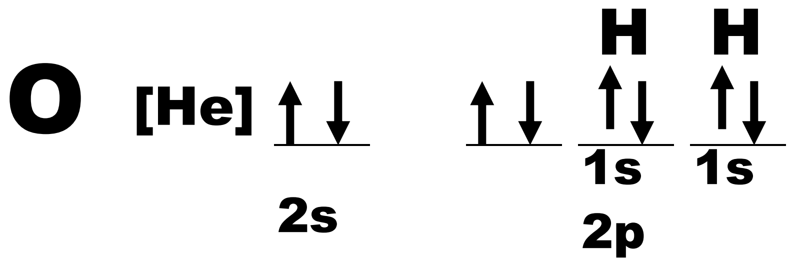
The unit of matter resulting from atoms joined by covalent bonds.

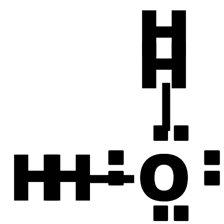
Covalent Bonds



The sharing of valence electrons


H
H
1s
1s
O
[He]
2s
2p


O
[He]
H
H
1s
1s
2s
2p



Covalent Bonding

- Sharing of valence electrons due to an overlapping of singlet orbitals.
- Usually occur between nonmetals.
- Forms a strong bond holding atoms together to form single units called molecules.
- Types of bonds: single, double, & triple

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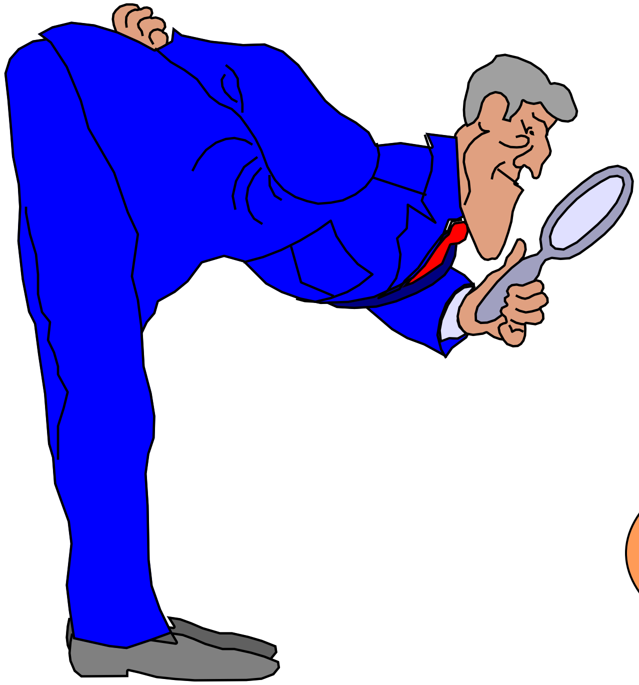
Electronegativity



Developed by
Linus Pauli

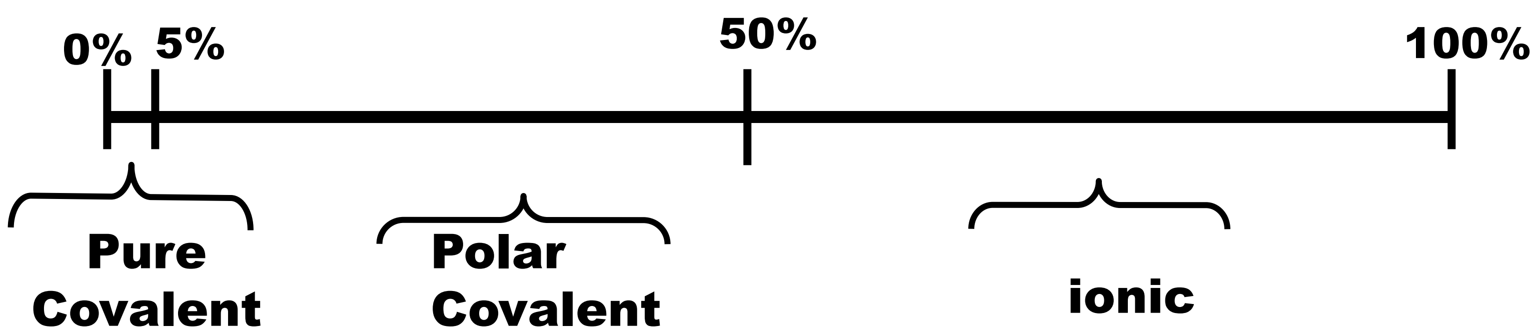
A measure of the attraction of an atom for the electrons in a chemical bond.

Increasing electronegativity →

Decreasing electronegativity ↓

				H 2.1												
Li 1.0	Be 1.5											B 2.0	C 2.5	N 3.0	O 3.5	F 4.0
Na 0.9	Mg 1.2											Al 1.5	Si 1.8	P 2.1	S 2.5	Cl 3.0
K 0.8	Ca 1.0	Sc 1.3	Ti 1.5	V 1.6	Cr 1.6	Mn 1.5	Fe 1.8	Co 1.9	Ni 1.9	Cu 1.9	Zn 1.6	Ga 1.6	Ge 1.8	As 2.0	Se 2.4	Br 2.8
Rb 0.8	Sr 1.0	Y 1.2	Zr 1.4	Nb 1.6	Mo 1.8	Tc 1.9	Ru 2.2	Rh 2.2	Pd 2.2	Ag 1.9	Cd 1.7	In 1.7	Sn 1.8	Sb 1.9	Te 2.1	I 2.5
Cs 0.7	Ba 0.9	La-Lu 1.0-1.2	Hf 1.3	Ta 1.5	W 1.7	Re 1.9	Os 2.2	Ir 2.2	Pt 2.2	Au 2.4	Hg 1.9	Tl 1.8	Pb 1.9	Bi 1.9	Po 2.0	At 2.2
Fr 0.7	Ra 0.9	Ac 1.1	Th 1.3	Pa 1.4	U 1.4	Np-No 1.4-1.3										

Electronegativity Differences between Bonding Atoms



$$\%\ \text{ionic character of bond A} - \text{B} = \frac{x_A - x_B}{x_A} \times 100\%$$

Since:

H		O
2.1	&	3.5

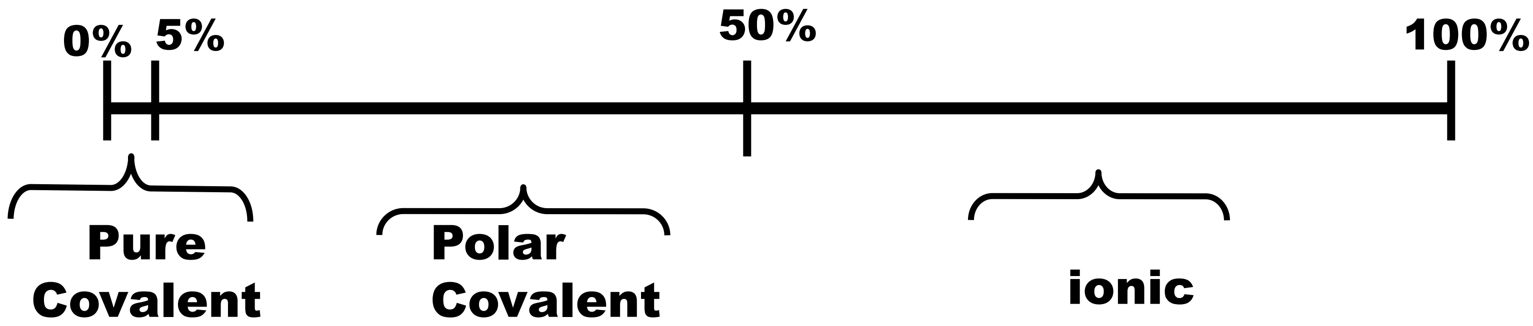
Therefore:

$$\%\ \text{ionic character of bond H} - \text{O} = \frac{3.5 - 2.1}{3.5} \times 100\%$$

Then:

$$\%\ \text{ionic character of bond H} - \text{O} = 40\%$$

Electronegativity Differences between Bonding Atoms



Increasing electronegativity →

Decreasing electronegativity ↓

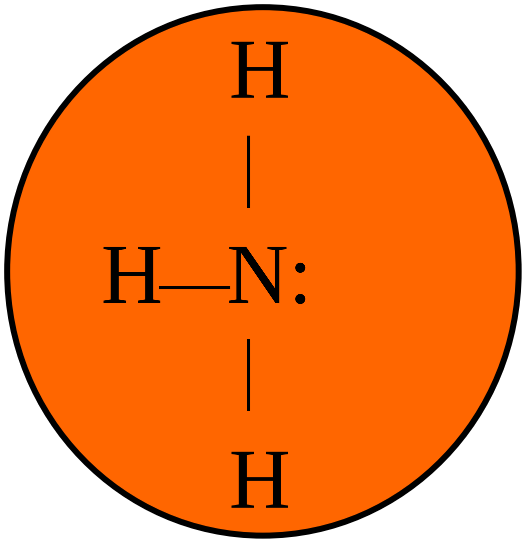
				H 2.1												
Li 1.0	Be 1.5											B 2.0	C 2.5	N 3.0	O 3.5	F 4.0
Na 0.9	Mg 1.2											Al 1.5	Si 1.8	P 2.1	S 2.5	Cl 3.0
K 0.8	Ca 1.0	Sc 1.3	Ti 1.5	V 1.6	Cr 1.6	Mn 1.5	Fe 1.8	Co 1.9	Ni 1.9	Cu 1.9	Zn 1.6	Ga 1.6	Ge 1.8	As 2.0	Se 2.4	Br 2.8
Rb 0.8	Sr 1.0	Y 1.2	Zr 1.4	Nb 1.6	Mo 1.8	Tc 1.9	Ru 2.2	Rh 2.2	Pd 2.2	Ag 1.9	Cd 1.7	In 1.7	Sn 1.8	Sb 1.9	Te 2.1	I 2.5
Cs 0.7	Ba 0.9	La-Lu 1.0-1.2	Hf 1.3	Ta 1.5	W 1.7	Re 1.9	Os 2.2	Ir 2.2	Pt 2.2	Au 2.4	Hg 1.9	Tl 1.8	Pb 1.9	Bi 1.9	Po 2.0	At 2.2
Fr 0.7	Ra 0.9	Ac 1.1	Th 1.3	Pa 1.4	U 1.4	Np-No 1.4-1.3										

Lewis Structures (Electron-Dot)

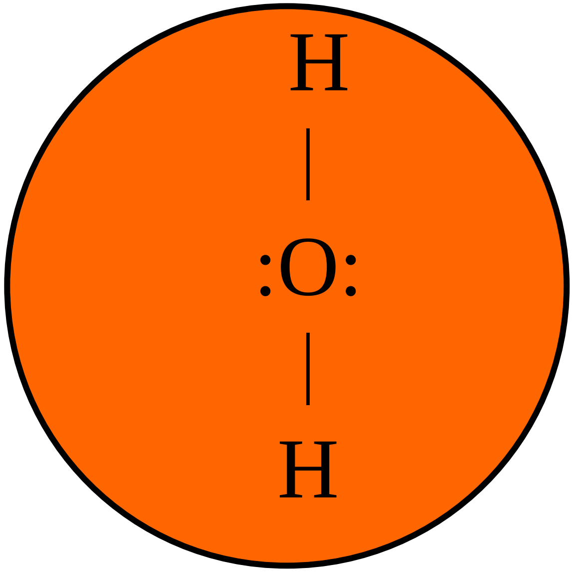
- Determine the total number of valence electrons in the molecule or ion
  - Molecules: add the number of valence electrons on each atom in the molecule
  - Anions: add the number of valence electrons on the atoms in the ion and the number of negative charges on the ion
  - Cations: add the number of valence electrons on the atoms in the ion and then subtract the number of positive charges on the ion

- Draw a skeleton of the molecule or ion, showing the arrangement of atoms, and connect each atom to another with a single bond.
- Deduct the 2 valence electrons for each bond.
- Distribute the remaining electrons as unshared pairs so that each atom has 8 electrons if possible.

Lewis Structures: Ammonia



Lewis Structures: Water



Lewis Structures

Noble Gas Configuration

vs

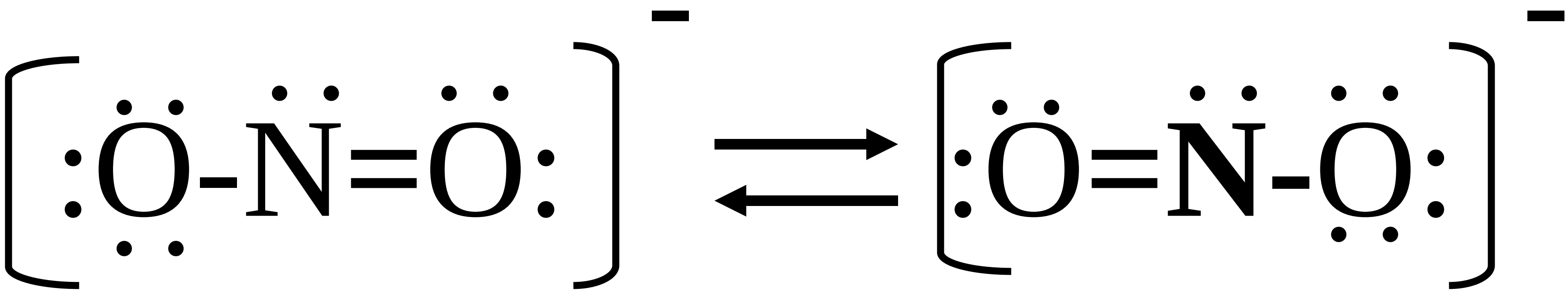
nonNoble Gas Configuration

Oxidation State (Number) or Valence Number

A hypothetical charge an atom would have if the electrons in each bond were located on the more electronegative atom.

Resonance

If two or more Lewis structures with the same arrangement of atoms can be written for a molecule or ion, then the actual electron distribution is an average of that shown by the various Lewis structures.



Bond Dissociation Energy

The energy required to break a specific covalent bond in exactly 1 mole of gaseous molecules.

Bond Dissociation Energy

$$H_{2(g)} \rightarrow 2H_{(g)} \qquad \Delta H^{o}_{298} = 436kJ$$

$$XY_{(g)} \rightarrow X_{(g)} + Y_{(g)} \qquad D_{x-y} = \Delta H^{o}_{298}$$

Calculation of Enthalpy Change

$$\Delta H = \sum D_{bonds\ broken} - \sum D_{bonds\ formed}$$

Single Bonds

H	C	N	O	F	Si	P	S	Cl	Br	I	
436	415	390	464	569	395	320	340	432	370	295	H
	345	290	350	439	360	265	260	330	275	240	C
		160	200	270	--	210	--	200	245	--	N
			140	185	370	350	--	205	--	200	O
				160	540	489	285	255	235	--	F
					230	215	225	359	290	215	Si
						215	230	330	270	215	P
							215	250	215	--	S
								243	220	210	Cl
									190	180	Br
										150	I

Multiple Bonds

C = C,	611	C = N,	615	C = O,	741	N = N,	418	O = O,	498
C ≡ C,	837	C ≡ N,	891	C ≡ O,	1080	N ≡ N,	946		


THE
END