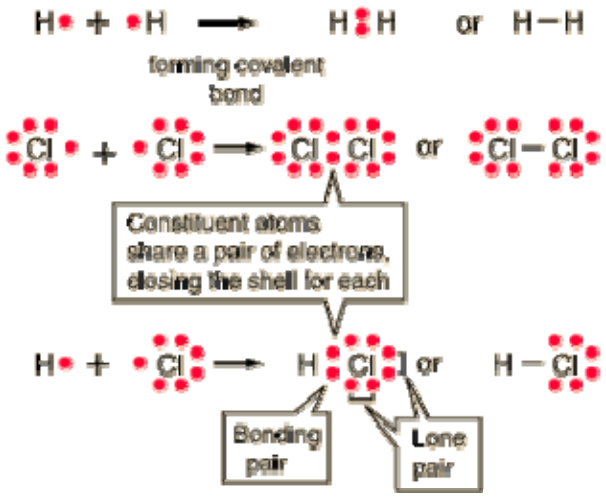
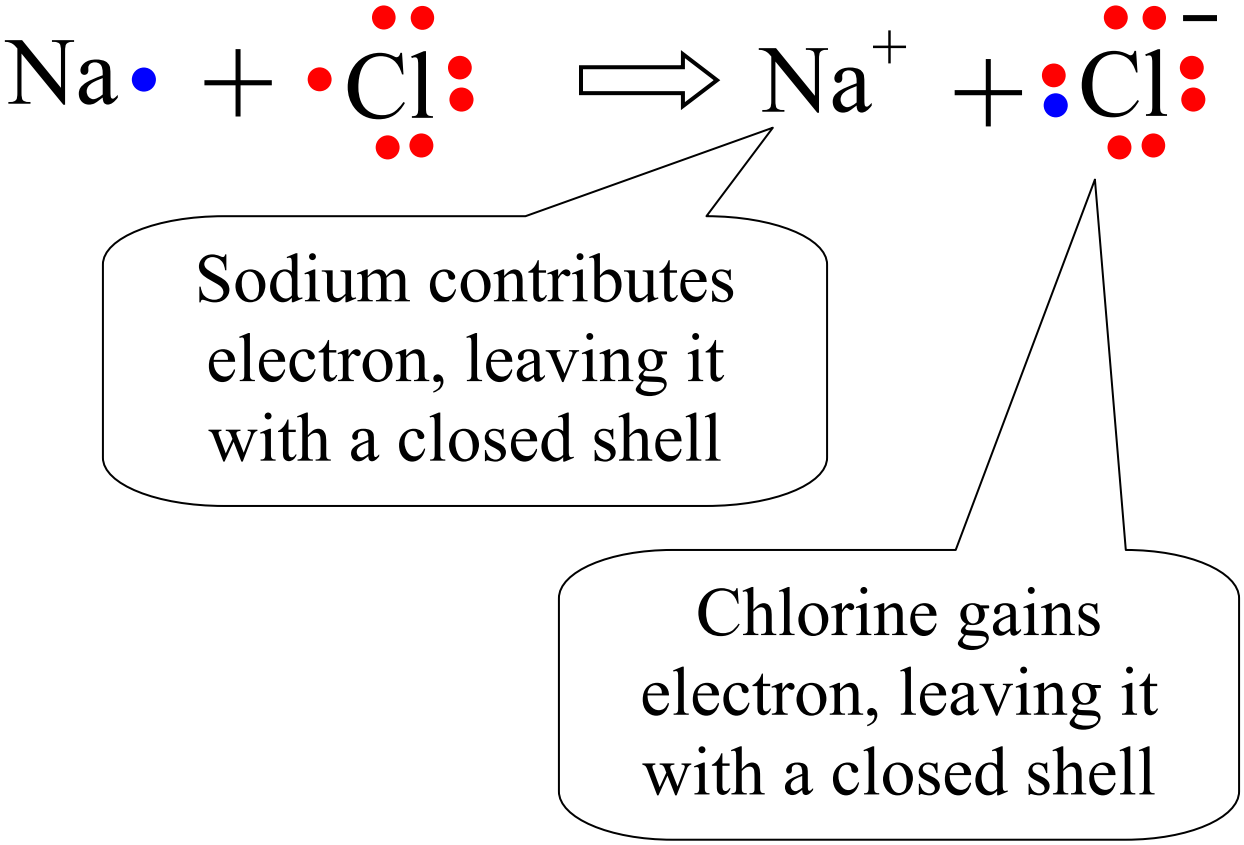
Covalent Bonds

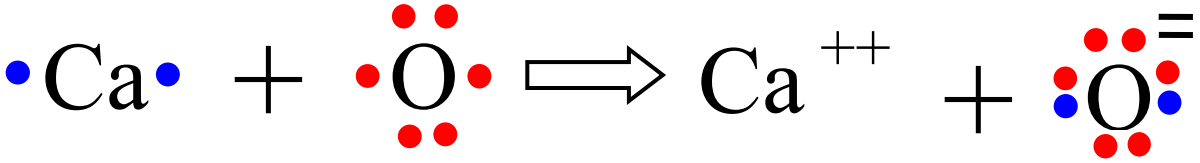
Covalent chemical bonds involve the sharing of a pair of valence electrons by two atoms, in contrast to the transfer of electrons in ionic bonds. Such bonds lead to stable molecules if they share electrons in such a way as to create a noble gas configuration for each atom.

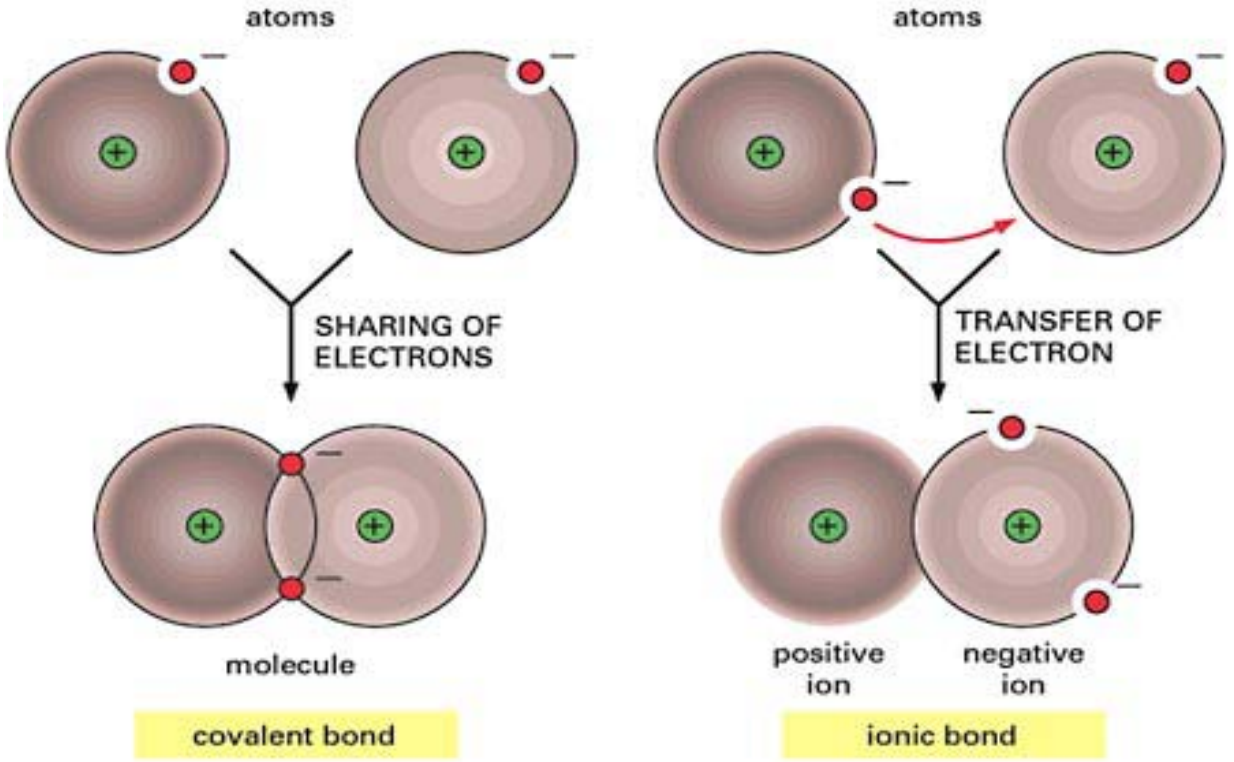
Hydrogen gas forms the simplest covalent bond in the diatomic hydrogen molecule. The halogens such as chlorine also exist as diatomic gases by forming covalent bonds. The nitrogen and oxygen which makes up the bulk of the atmosphere also exhibits covalent bonding in forming diatomic molecules.

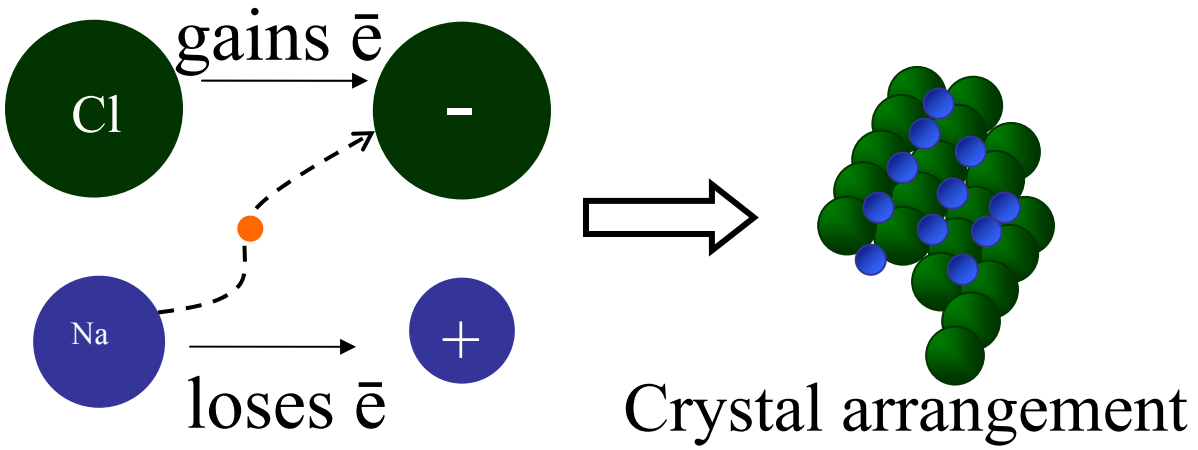


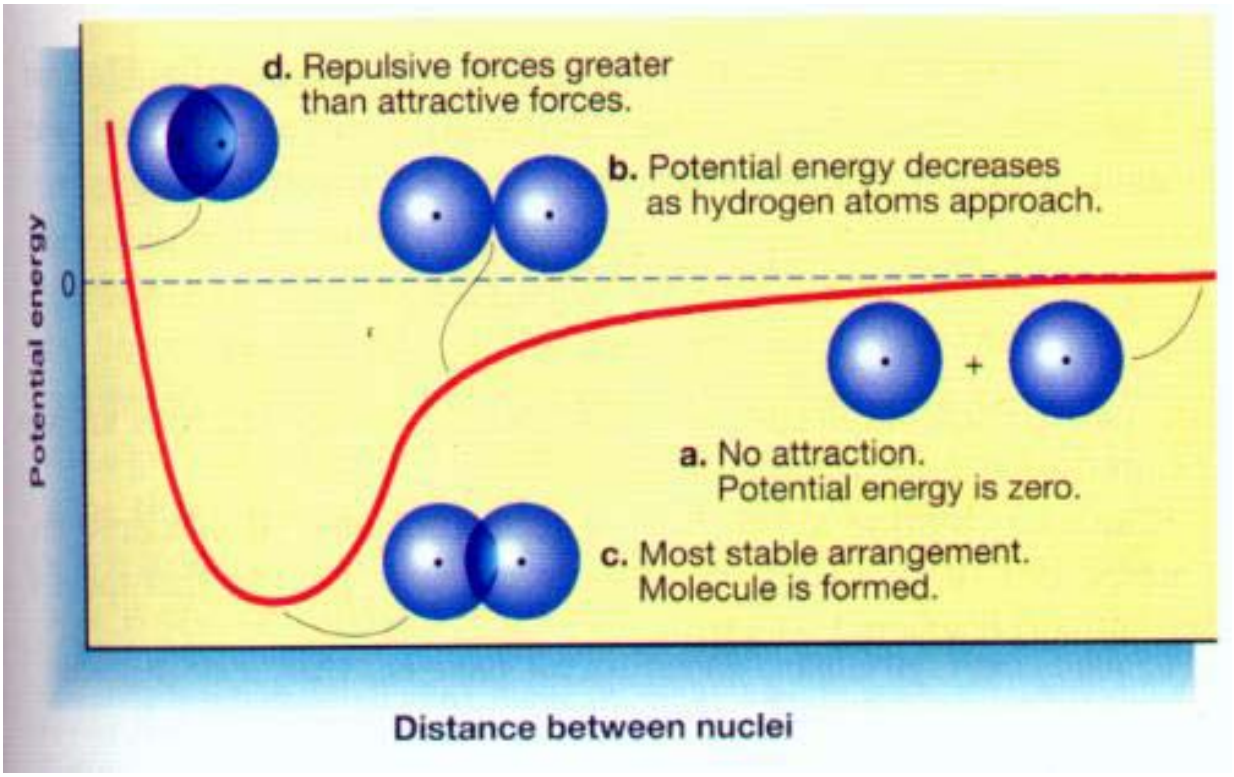
Covalent bonding can be visualized with the aid of Lewis diagrams


Na + Cl ⟹ Na+ + Cl−
Sodium contributes electron, leaving it with a closed shell
Chlorine gains electron, leaving it with a closed shell


Ca + O ⟹ Ca++ + O=


atoms
SHARING OF ELECTRONS
molecule
covalent bond
atoms
TRANSFER OF ELECTRON
positive ion
negative ion
ionic bond


gains ē
Cl
-
Na
+
loses ē
Crystal arrangement

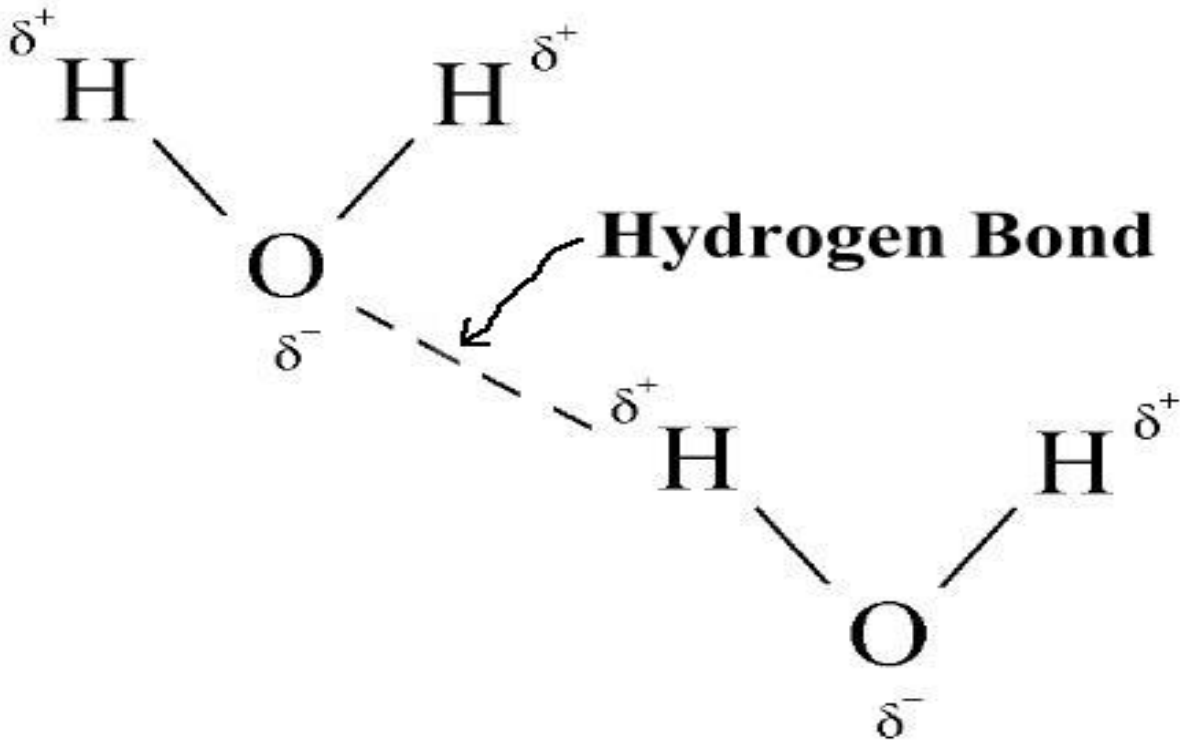


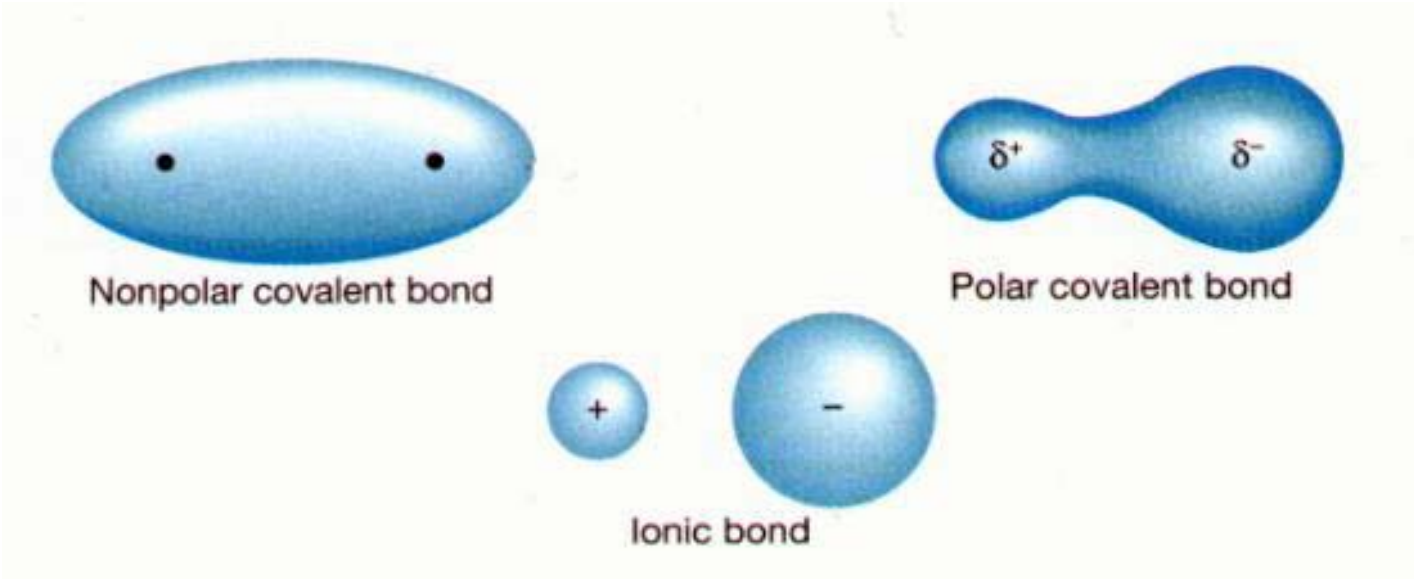
Electronegativities of the Elements

1A	2A											3A	4A	5A	6A	7A
2.1 H																
1.0 Li	1.5 Be											2.0 B	2.5 C	3.0 N	3.5 O	4.0 F
0.9 Na	1.2 Mg											1.5 Al	1.8 Si	2.1 P	2.5 S	3.0 Cl
0.8 K	1.0 Ca	1.3 Sc	1.5 Ti	1.6 V	1.6 Cr	1.5 Mn	1.8 Fe	1.8 Co	1.8 Ni	1.9 Cu	1.6 Zn	1.6 Ga	1.8 Ge	2.0 As	2.4 Se	2.8 Br
0.8 Rb	1.0 Sr	1.2 Y	1.4 Zr	1.6 Nb	1.8 Mo	1.9 Tc	2.2 Ru	2.2 Rh	2.2 Pd	1.9 Ag	1.7 Cd	1.7 In	1.8 Sn	1.9 Sb	2.1 Te	2.5 I
0.7 Cs	0.9 Ba	1.1–1.2 La–Lu	1.3 Hf	1.5 Ta	1.7 W	1.9 Re	2.2 Os	2.2 Ir	2.2 Pt	2.4 Au	1.9 Hg	1.8 Tl	1.8 Pb	1.9 Bi	2.0 Po	2.2 At
0.7 Fr	0.9 Ra	1.1–1.7 Ac–Lr														

Decreasing electronegativity

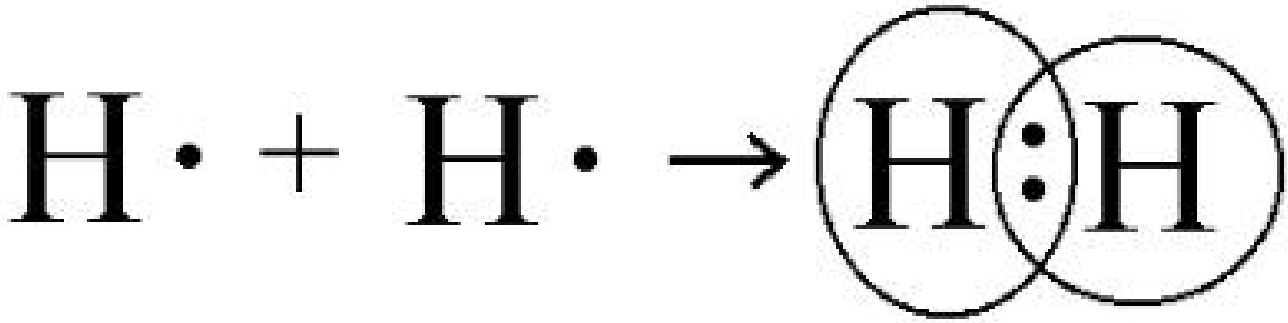
Increasing electronegativity

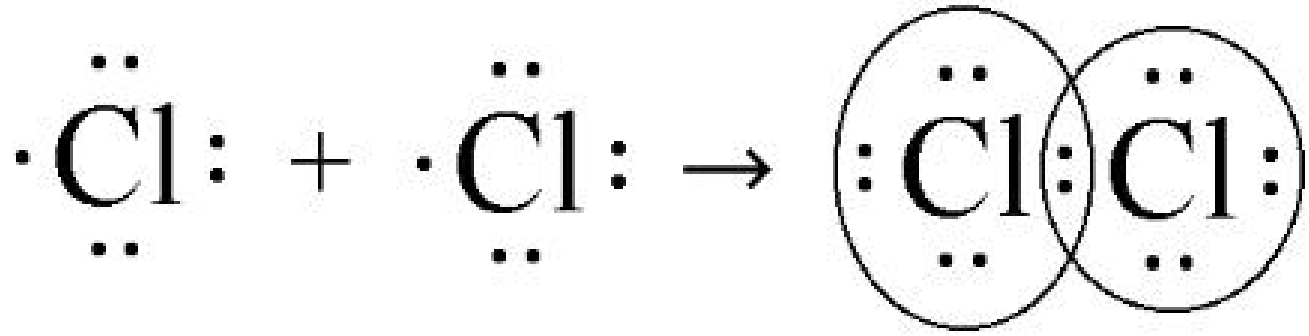

δ+
H
H
δ+
O
δ−
Hydrogen Bond
δ+
H
H
δ+
O
δ−


Nonpolar covalent bond
δ+
δ−
Polar covalent bond
+
−
Ionic bond

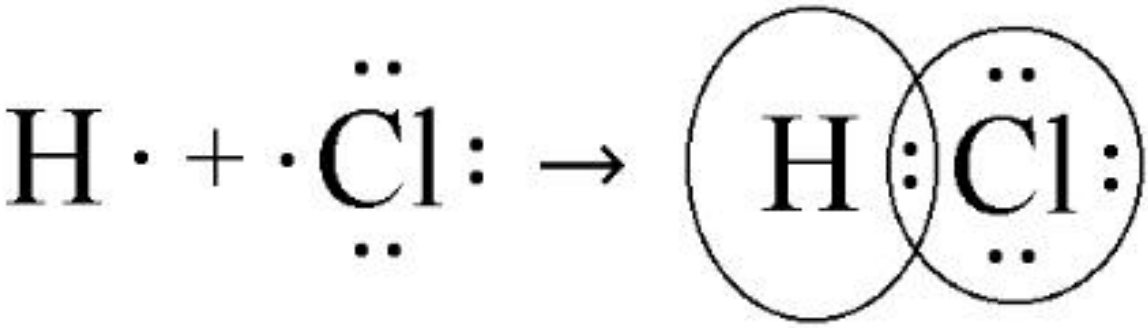
Covalent Bonds:

EQUAL SHARING OF ELECTRONS:



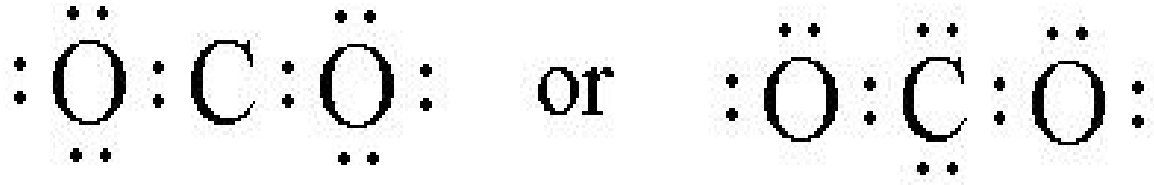


UNEQUAL SHARING OF ELECTRONS:

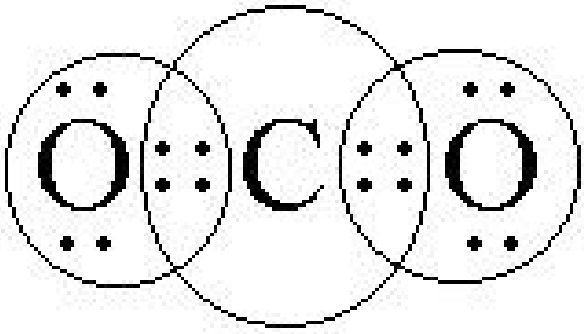


DOUBLE AND TRIPLE BONDS:

Try to draw the Lewis Dot symbol for carbon dioxide, CO_2. You will encounter a problem. Carbon has 4 valence electrons, and the two oxygen together have 12 ,(2 x 6), for a **total of 16 electrons**. The two possible structures that can be drawn for carbon dioxide can be these:



In either case, carbon or oxygen will not have eight electrons represented. However, if each oxygen atoms shares two pairs of electrons with the carbon atom, double bonds would be formed, and octets around both carbon and oxygen can be achieved.

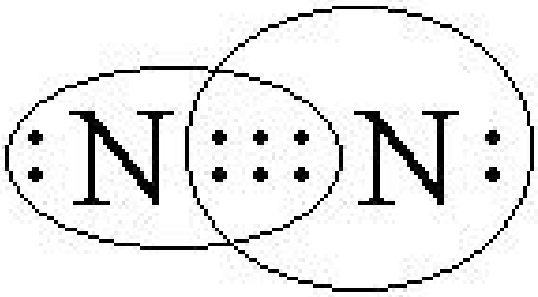


The circles are drawn to represent the octet for each atom.

A Double Bond is a covalent bond in which four electrons (two pairs) are shared by the bonding atoms.

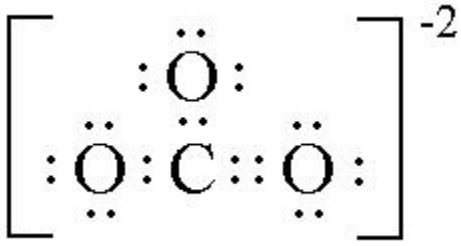
Triple Bond is a covalent bond in which two atoms share three pairs of electrons.

Nitrogen gas is an example of a triple bond.



EQUIVALENT LEWIS DOT SYMBOLS (RESONANCE STRUCTURES):

Some molecules and polyatomic ions have properties that cannot be adequately explained by a single Lewis Dot symbol. An example is the carbonate ion, CO_3^{-2}. One Lewis Dot Symbol that fulfills the **octet rule** is:

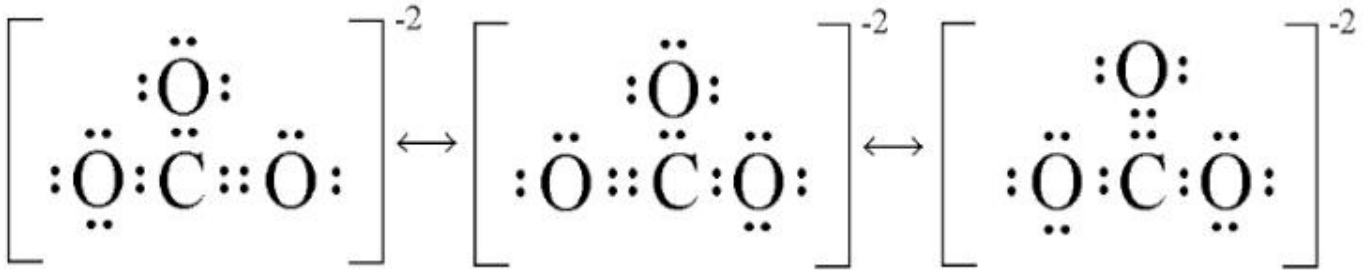


However, the double bond could be on any oxygen atom (not just the oxygen atom that is pictured). Therefore, there are three possible Lewis dot symbols possible for carbonate.

However, experimental studies show that all three of the carbon-oxygen bonds are identical; there is no evidence of both single and double bonds. In fact, the bonds are stronger than a carbon-oxygen single bond and weaker than a carbon-oxygen double bond. This phenomenon is called RESONANCE.

Resonance is often represented by writing each of the different Lewis Dot Symbols and including double-headed arrows

between the possible
symbol.

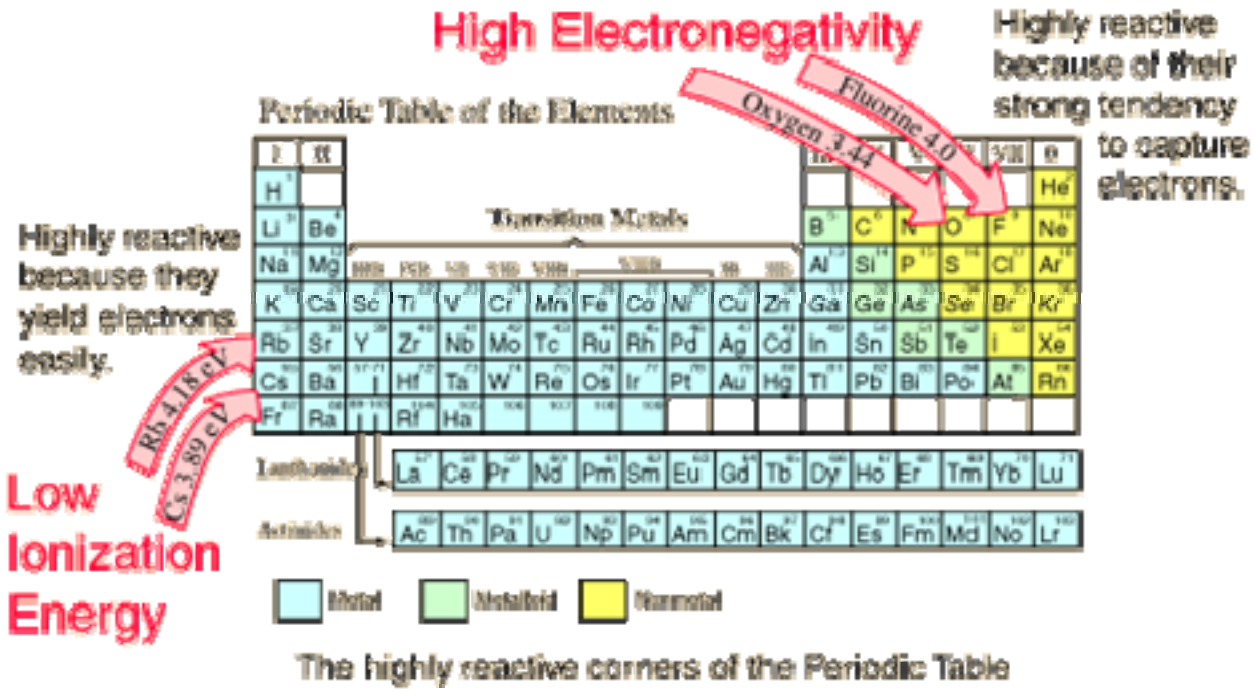


Electronegativity

Electronegativity is a measure of the ability of an atom in a molecule to draw bonding electrons to itself.

The most commonly used scale of electronegativity is that developed by Linus Pauling in which the value 4.0 is assigned to fluorine, the most electronegative element.

An important application of electronegativity is in the prediction of the polarity of a chemical bond.



Lewis Dot Diagrams of Selected Elements