Chemical Bonding

What holds things together?

PGCC CHM 101Sinex

Let's examine the melting point of compounds across two periods. What is the trend?

Conductivity - high Conductivity - low

Chlorides of Period 2							
compound	LiCl	$BeCl_2$	BCl_3	CCl_4	NCl_3	OCl_2	Cl_2
melting point			-107	-23	-40	-121	-102
Chlorides of Period 3							
compound	NaCl	$MgCl_2$	$AlCl_3$	$SiCl_4$	PCl_3	SCl_6	Cl_2
melting point				-69	-112	-51	-102

high low

CRC *Handbook of Chemistry and Physics* 1995

Bonding

Can we explain the melting point behavior across a period?

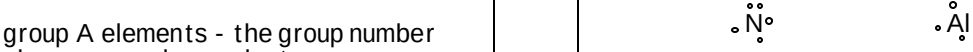
- involves the valence electrons or outermost shell (or highest shell) electrons
- for group A elements - the group number tells how many valence electrons

How many valence electrons on N?

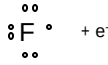
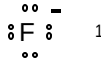
Group 5A – 5 valence electrons

Bonding…

- Lewis dot structures show the valence electrons around at atom and for most molecules and compounds a complete octet for the elements



- most monatomic ions have an electron configuration of noble gases

$1s^2\underline{2s^2 2p^5}$  $+ e^- \rightarrow$  $1s^2\underline{2s^2 2p^6}$ Ne

Write out the electron configuration for the following atoms and ions:

He	H^-
Ne	Ca^{+2}
Ar	O^{-2}
Kr	Br^-

Which noble gas is isoelectronic with each ion?

NaCl This is the formation of an ionic bond.

electron transfer
and the formation of ions

Cl_2 This is the formation of a covalent bond.

sharing of a pair of electrons
and the formation of molecules

What about the distance between the atoms in a bond?

NaCl $Na^+ Cl^-$ d = 281 pm

Cl_2 Cl-Cl d = 199 pm

What property can be used to tell when a bond will ionic or covalent?

Draw the Lewis dot structures for the following compounds:

ionic

MgO $CaCl_2$ Na_2S

covalent

HCl H_2O CH_4

Some exceptions to the Octet Rule

BF_3

PCl_5

SF_6

Electronegativity

The electronegativity difference - $\Delta EN = EN_{higher} - EN_{lower}$

Chlorides of Period 2							
compound	LiCl	$BeCl_2$	BCl_3	CCl_4	NCl_3	OCl_2	Cl_2
ΔEN	2.2	1.6	1.1	0.6	0	0.6	0
Chlorides of Period 3							
Compound	NaCl	$MgCl_2$	$AlCl_3$	$SiCl_4$	PCl_3	SCl_6	Cl_2
ΔEN	2.2	1.9	1.6	1.3	1.0	0.6	0

large difference small difference

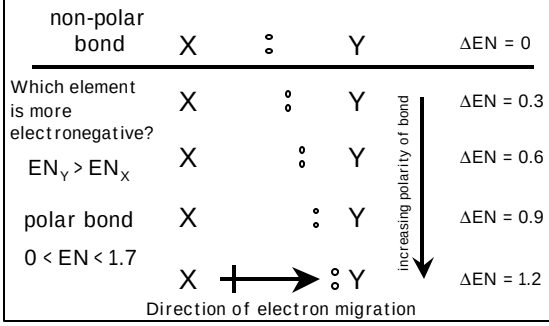
Using electronegativities to determine bond type

$\Delta EN > 1.7$ ionic bond - transfer

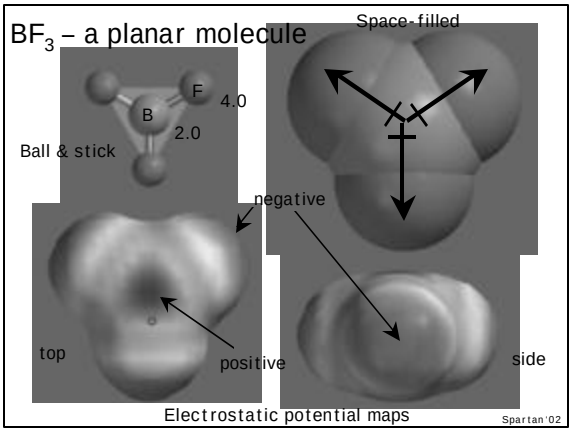
$\Delta EN < 1.7$ covalent bond - sharing

So we have a range of electronegativity difference of 0 to 1.7 for sharing an electron pair.

Is the sharing of electrons in molecules always equal?



BF_3 – a planar molecule

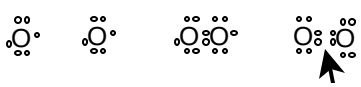


Electrostatic potential maps

Spartan'02

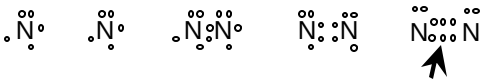
More sharing examples

O_2 Share until octet is complete.



double bond (2 pairs)

N_2 octet complete



triple bond (3 pairs)

Bond Energy

Is breaking a bond an endothermic or exothermic process?

X_2 + energy → X + X

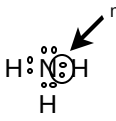
F_2	single bond	BE = 142 kJ/mole
O_2	double bond	BE = 494
N_2	triple bond	BE = 942

increasing bond strength

http://wulfenite.fandm.edu/Data%20/Table_6.html

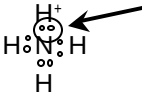
Some more sharing examples

NH_3



normal covalent bond (each atom supplies an electron)

NH_4^+ $NH_3 + H^+ \rightarrow NH_4^+$

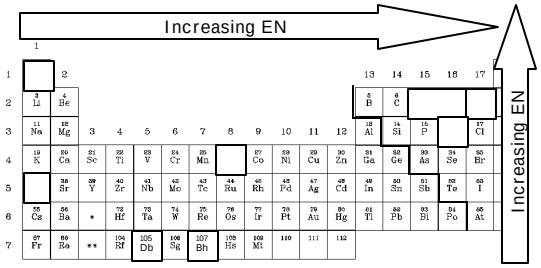


coordinate covalent bond (the pair of electrons from the same atom)

Type of bond? – I, PC, or NC

TiO_2	CH_4	NaI
CS_2	CO_2	KCl
$AlCl_3$	CsF	HBr

Using the EN trends to predict bond type



NO RbF FeS H_2S

Modified from http://www.cem.msu.edu/~djm/cem384/ptable.html

Draw the Lewis dot structures

CO_2 NH_2^-

H_3O^+ CO

HCN H_2CO

(C in center)

Show the direction of electron migration (⟶) in the following.

C – H

H – F

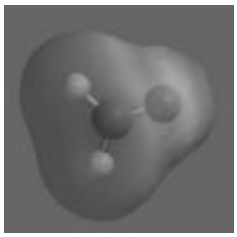
C = O

C – Cl

Rank the bond polarity (1-most … 3-least)

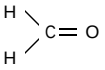
As-H N-H P-H

Here is the electrostatic potential map for H_2CO.



blue – positive red - negative

Show the electron migration on this planar molecule.



How is this molecule different than BF_3?

Comparison of Bonding Types