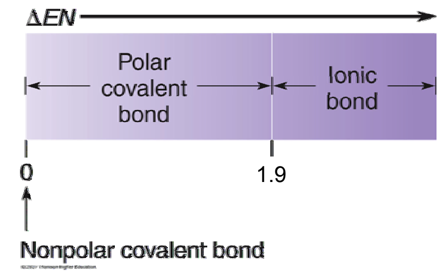
Chemistry 6A Fall 2007

Dr. J. A. Mack

Wednesday

10/10/07

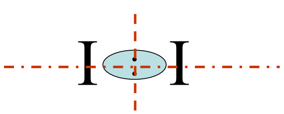


Br-Br	H-F	Cs-F
completely molecular in character	*somewhere in between (polar covalent)*	*completely ionic in character*

Overall Polarity in molecules:

The polarity of the individual bonds in a molecule will determine the overall polarity of a molecule.

All ***homonuclear*** diatomic molecules a non-polar.



iodine (I_2)

Notice the symmetry of the molecule:

When divided, the top and bottom as well as the left and right are mirror images of one another.

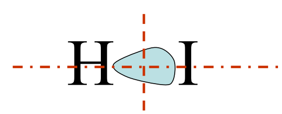
One also knows the molecule is non polar because the bond is non polar.

$$\Delta EN = 2.5 - 2.5 = 0$$

Overall Polarity in molecules:

The polarity of the individual bonds in a molecule will determine the overall polarity of a molecule.

All ***heteronuclear*** diatomic molecules a non-polar.



Hydrogen iodide (HI)

Notice the symmetry of the molecule:

When divided, the top and bottom as well as the left and right are not mirror images of one another.

One also knows the molecule is polar because the bond is polar.

$$\Delta EN = 2.5 - 2.1 = 0.4$$

Molecular Polarity:

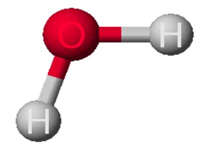
	Water	Methane
Formula	H_2O	CH_4
Molar mass	18.02 g/mol	16.04 g/mol
Boiling point	100°C	-161 °C

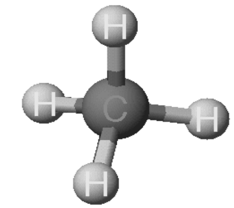
Why is there such a great difference?

Molecular Polarity:

To explain the difference in boiling points, let's look at the shapes of the molecules:

H_2O





CH_4

Notice that water is "asymmetric" and methane is "symmetric".

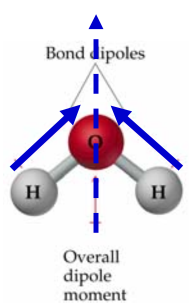
The lack of symmetry means that water is "polar" which allows for stronger *intermolecular attractive forces*, thus the higher boiling point.

Molecular Shape and Molecular Polarity

When a molecule possesses a net dipole moment, it is polar.

H_2O

The individual O-H bond polarities result in a "net" or overall polarity for the molecule.

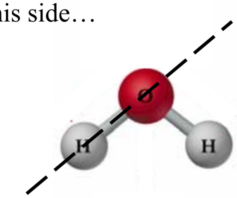


The molecule is therefore polar

Molecular Shape and Molecular Polarity

Notice also that the molecule's symmetry can be broken along either O-H bond axis:

This side…

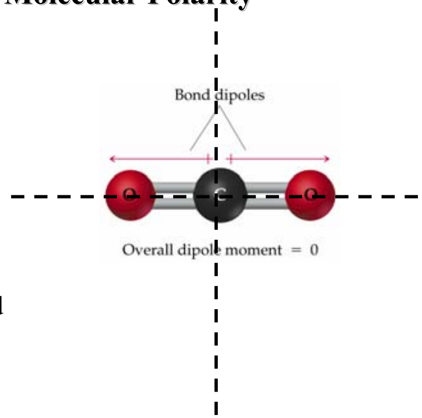


does not look like this side!

Whenever there exists a line or plane of asymmetry, the molecule is Polar!

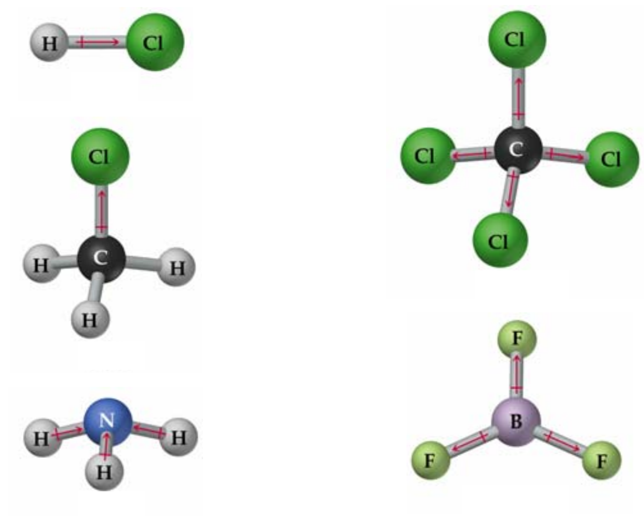
Molecular Shape and Molecular Polarity

CO_2

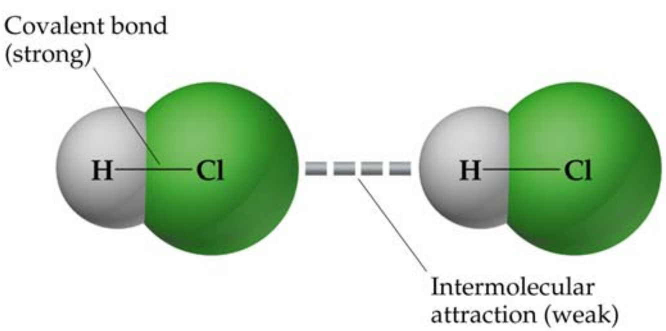


Symmetry across all bond axes.

non–polar



Forces Between Particles:



Intermolecular forces are much weaker than the bonds that make up compounds.

Ion-Ion Forces: Formal charges, strongest IMF

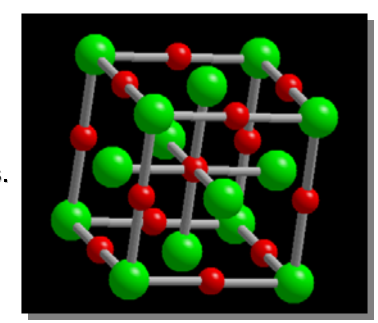
Na^+--- Cl^- in salt

These are the strongest forces.

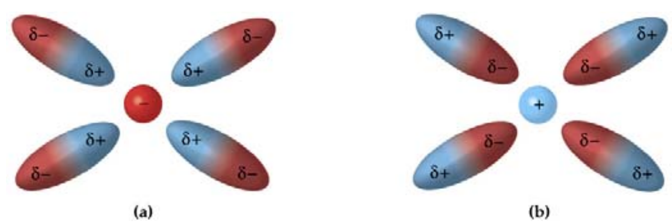
Lead to solids with high melting temperatures.

NaCl, mp = 800 °C

MgO, mp = 2800 °C



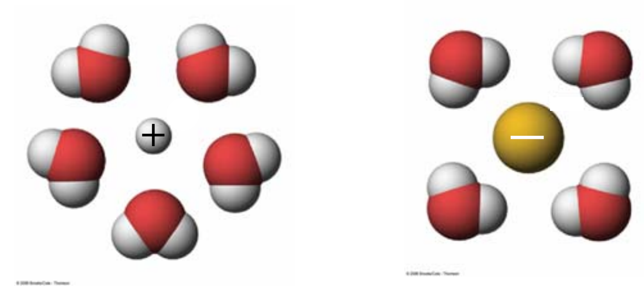
Ion–Dipole Intermolecular Forces (IMF):



The strongest IMF:

The partial charge of the dipole is attracted to the formal charge on the ion.

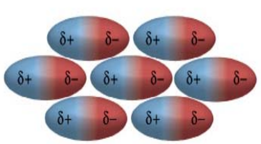
Solvation of ions:



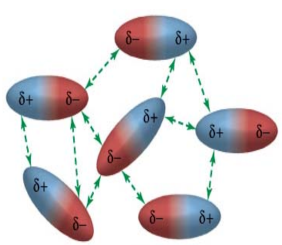
When a *cation* exists in solution, it is surrounded by the *negative* dipole ends of water molecules.

When as *anion* exists in solution, it is surrounded by the *positive* dipole ends of water molecules.

Dipole – Dipole Intermolecular Forces (IMF):



Solid Phase

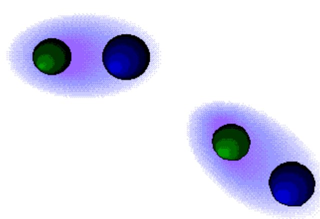


Liquid Phase

The partial charge of the dipoles are attracted to one another.

The second most strong IMF

Dipole – Dipole Intermolecular Forces



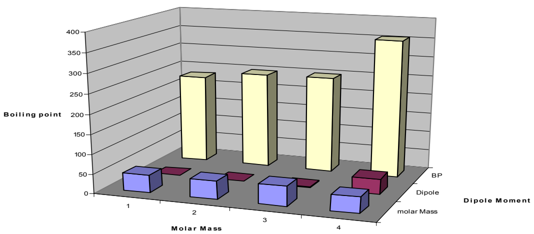
The greater the polarity of a molecule, the stronger the dipole–dipole interaction.

HF(g) > HCl(g) > HI (g)

Dipole – Dipole Intermolecular Forces

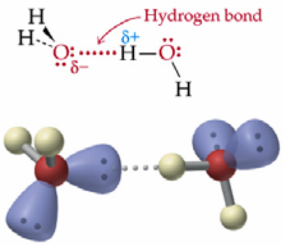
As the polarity for a given set of molecules with similar molar masses increases, the boiling point increases.

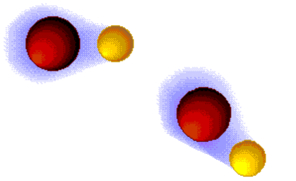
Substance	Mol Mass (amu)	Dipole Moment (D)	bp (K)
$CH_3CH_2CH_3$	44.10	0.1	231
CH_3OCH_3	46.07	1.3	248
CH_3Cl	50.49	1.9	249
CH_3CN	41.05	3.9	355



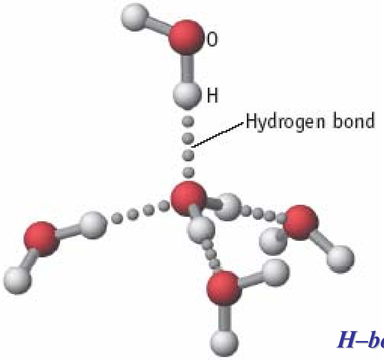
Hydrogen Bonding: Special dipole–dipole interaction

H–bonding occurs between molecules containing N–H, O–H, or F–H groups





The H–atoms are "swapped" between the higher electronegative atoms thus enhancing the attractive forces.

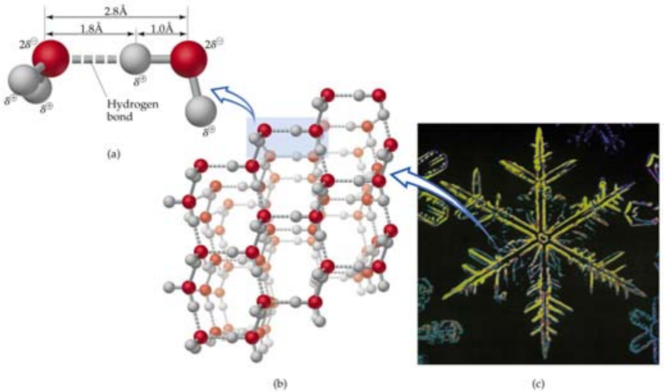


The water molecules network with one another.

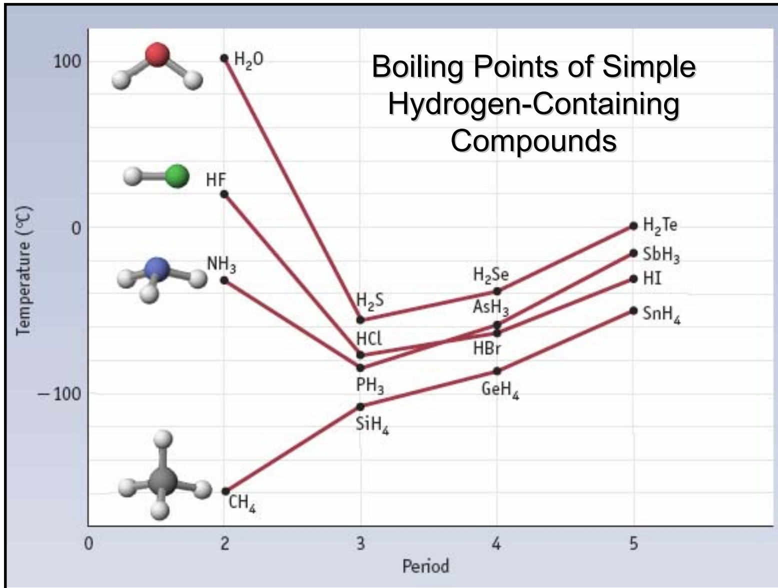
H–bonding in water brings about a network of interactions which explain phenomena such as:

capillary action surface tension why ice floats

Ice, $H_2O(s)$ floats because it is less dense than water, $H_2O(l)$.
The H–bonds allow the molecules in the liquid phase to to approach closer than normal for non H–bonding liquids.
This is why water has its maximum density at 4°C.

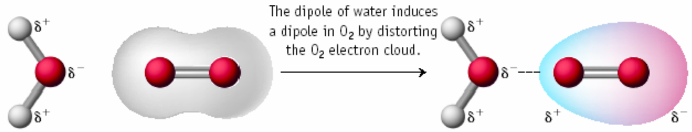


A consequence of hydrogen bonding



Induced Dipole Forces:

How can non-polar molecules such as O_2 and I_2 dissolve in water?



The water dipole ***INDUCES*** a dipole in the O_2 electric cloud.

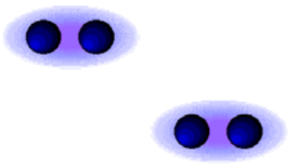
Once polarized, the O_2 is attracted to additional water molecules.

Dispersion Forces: Weakest of all intermolecular forces.

The forces that hold non–polar molecules together can be explained as follows:

Attractions arise from instantaneous, temporary dipoles formed due to electron motions.

The electron cloud of a molecule can be polarized to produce a short lived dipole that results in an attractive force.

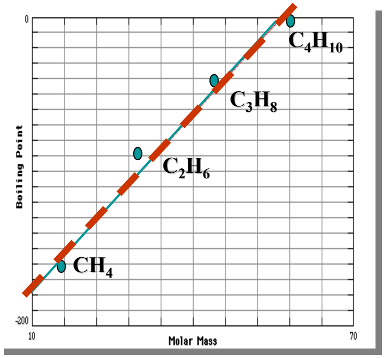


For molecules with the same relative shape, the forces scale with molar mass:

Higher molec. weight → larger induced dipoles.

Molecule	Boiling Point (°C)
CH_4 (methane)	- 161.5
C_2H_6 (ethane)	- 88.6
C_3H_8 (propane)	- 42.1
C_4H_{10} (butane)	- 0.5

Note linear relation between bp and molar mass.



Dispersion Forces:

As molar mass increases amongst non–polar molecules, bp and mp increase due to the increased polarizability of the molecule.

Halogen	mp (K)	bp (K)
F_2	53.5	85.0
Cl_2	172.2	238.6
Br_2	265.9	331.9
I_2	386.7	457.5

Chapter 5: Chemical Reactions:

Reactants → **Products**

Compounds or Molecules → New Compounds or Molecules