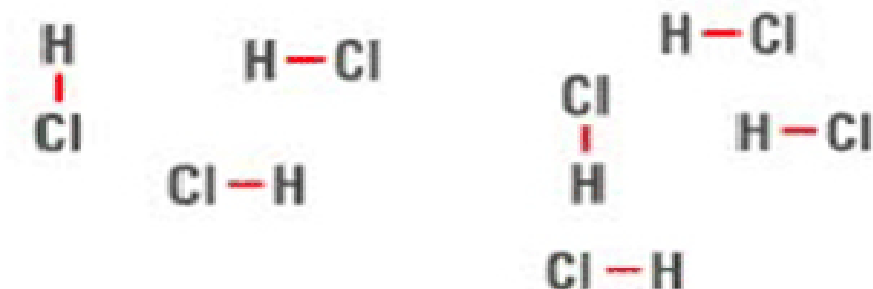


## 11.4 The Nature of Intermolecular Forces

### Dipole – Dipole

	<b>M</b> g/mol	<b>B.P.</b> °C
CO	28	-192
PH <sub>3</sub>	34	-88
AsH <sub>3</sub>	78	-62
ICI	162	97



The higher the **Boiling Point** the stronger the **Intermolecular Force** ... translate ... the stronger the glue holding it together.

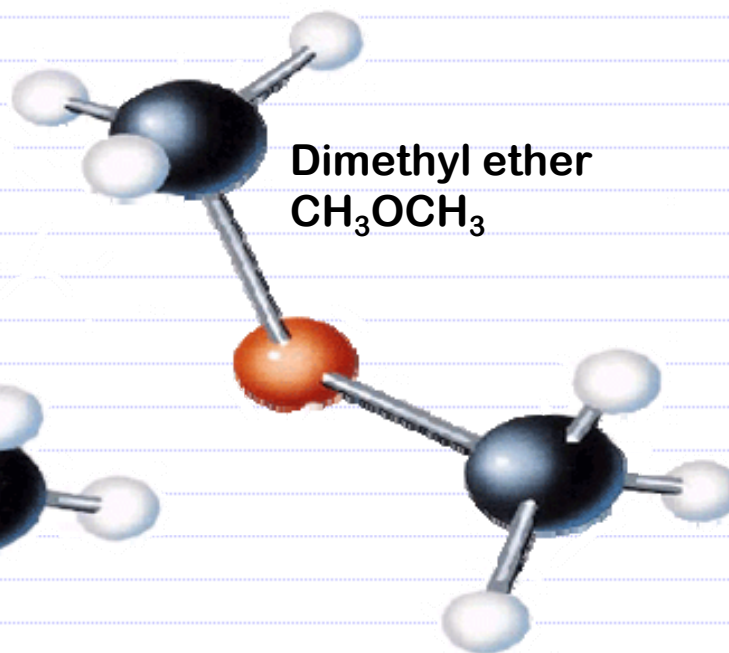
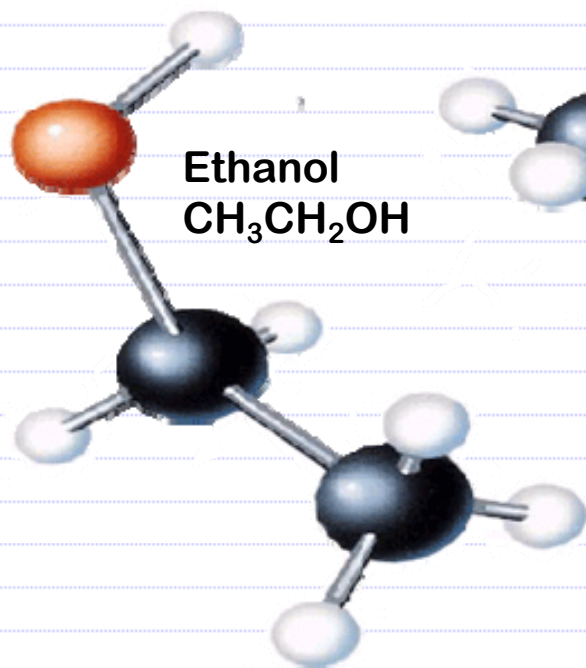
Note: See anything with respect to **Molar Mass** and **Boiling Point**?

See the obvious trend.

## 11.4 The Nature of Intermolecular Forces

### Dipole – Dipole – A Special Case – Hydrogen Bonding

A very interesting thing occurs when a dipole is the result of a  $H-(N,O,F)$  bond, due to the small size of H and the large electronegativity of Nitrogen, Oxygen and Fluorine, the resultant dipole-dipole interaction is much stronger than expected.  $N-H$ ,  $O-H$ ,  $F-H$ , form what we call **Hydrogen Bonds**.

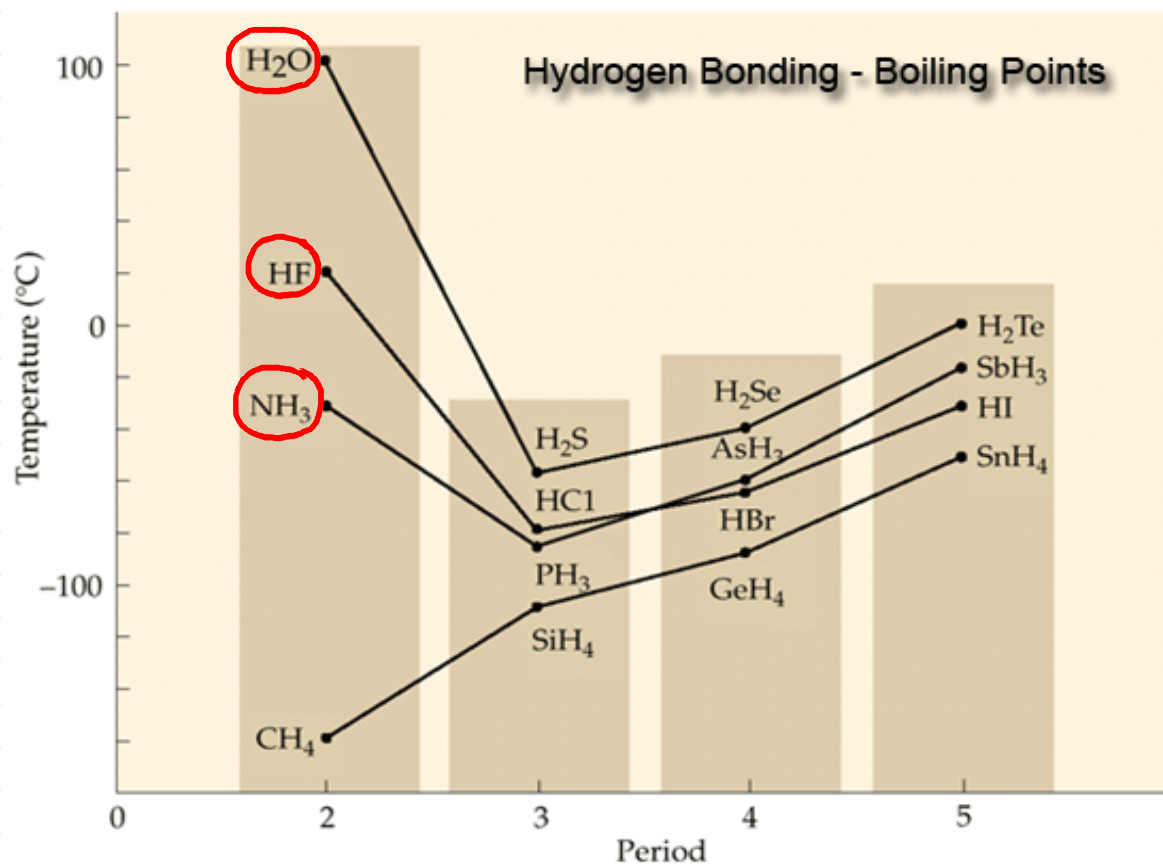


$CH_3OCH_3$ :  
Dimethyl ether, Dipole/Dipole  
Intermolecular Force but no  
Hydrogen Bond.  
Boiling Point:  $34.6^\circ C$

$CH_3CH_2OH$ :  
Ethanol, Dipole/Dipole  
Intermolecular Force with a  
Hydrogen Bond.  
Boiling Point:  $78.5^\circ C$

## 11.4 The Nature of Intermolecular Forces

### Dipole – Dipole – A Special Case – Hydrogen Bonding



H<sub>2</sub>Te, H<sub>2</sub>Se, H<sub>2</sub>S, H<sub>2</sub>O\*  
 Molecular Geometry, angular, all are polar. Dipole/Dipole IMF's.

HI, HBr, HCl, HF\*  
 Molecular Geometry, linear, all are polar. Dipole/Dipole IMF's.

SbH<sub>3</sub>, AsH<sub>3</sub>, PH<sub>3</sub>, NH<sub>3</sub>\*  
 Molecular Geometry, trigonal pyramid, all are polar. Dipole/Dipole IMF's.

SnH<sub>4</sub>, GeH<sub>4</sub>, SiH<sub>4</sub>, CH<sub>4</sub>  
 Molecular Geometry, tetrahedron, all are nonpolar.

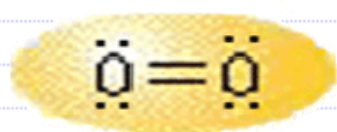
\*: These three molecules contain a Hydrogen Bond.

## 11.4 The Nature of Intermolecular Forces

### Dipole – Induced Dipole

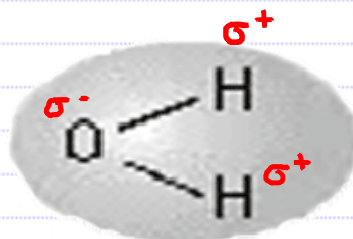
Oxygen (non-polar) dissolved in water (polar)

*Fish live in water – where do they get their oxygen from?*



No Dipole

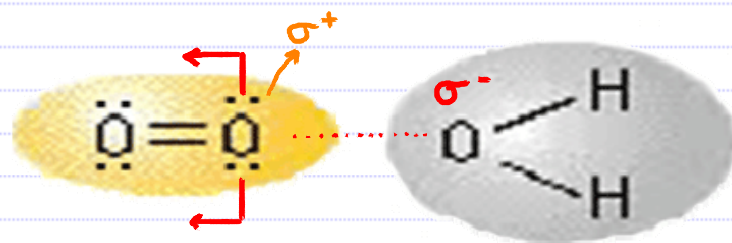
Nonpolar



Polar

The Solubility of Some Gases in Water

Gas	Molar Mass g/mol	Solubility @ 20°C g/100g Water
H <sub>2</sub>	2.01	0.000160
N <sub>2</sub>	28.0	0.000190
O <sub>2</sub>	32.0	0.000434
Cl <sub>2</sub>	70.9	0.729



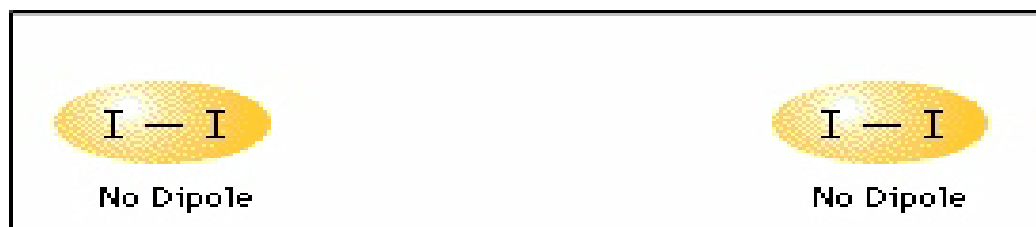
Induced Dipole

**NOTICE:** While the solubility is relatively small it does increase with increasing Molar Mass. The larger the molecule the easier it becomes to induce a dipole.

**11.4 The Nature of Intermolecular Forces**  
**Induced Dipole – Induced Dipole – aka London Dispersion Forces**

*I<sub>2</sub> is non-polar yet it exists as a solid?*

Chemistry Interactive: Induced Dipoles in Neighboring I<sub>2</sub> Molecules



[See Class Web Site](#)