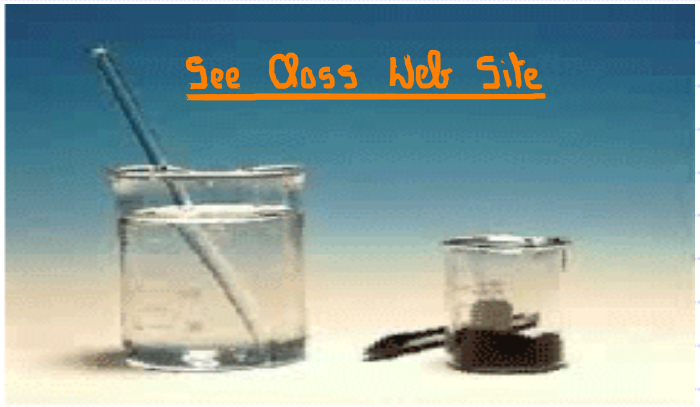
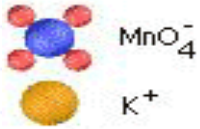
11.4 The Nature of Intermolecular Forces

Ion – Dipole – The Dissolution Process

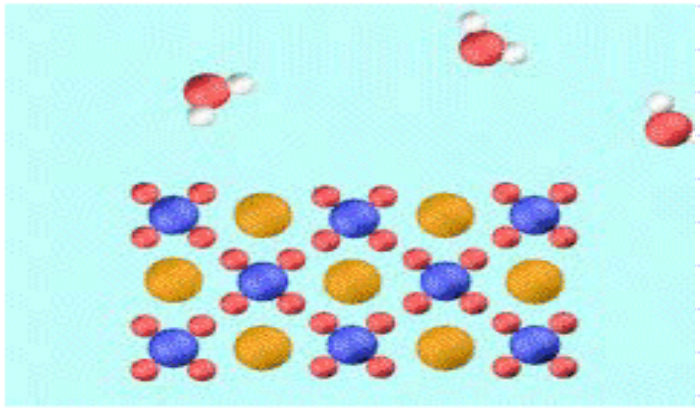
Macroscopic Scale



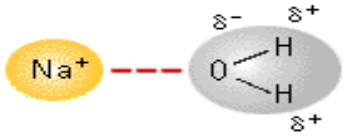
$H_2O(\ell)$ $KMnO_4(s)$



Nano Scale



Enthalpy of Hydration : A measure of the Ion / Dipole glue – the amount of energy given off when an ion is surrounded (usually by 6) by water molecules



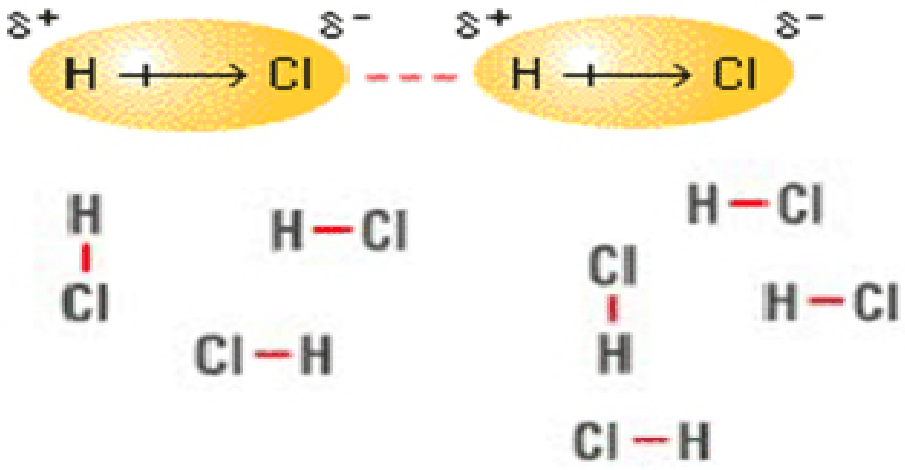
	Cation	Ion Radius pm	Enthalpy of Hydration kJ
a ✓	Li^+	90	-515
b	Na^+	116	-405
c	K^+	152	-312
d	Rb^+	166	-296
e	Cs^+	181	-263

Which of the above cations has the greatest Ion/Dipole interaction – strongest binding glue!

11.4 The Nature of Intermolecular Forces

Dipole – Dipole

Molar Masses Vs Boiling Points		
	M	B.P.
	g/mol	°C
CO	28	-192
PH_3	34	-88
AsH_3	78	-62
ICl	162	97



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

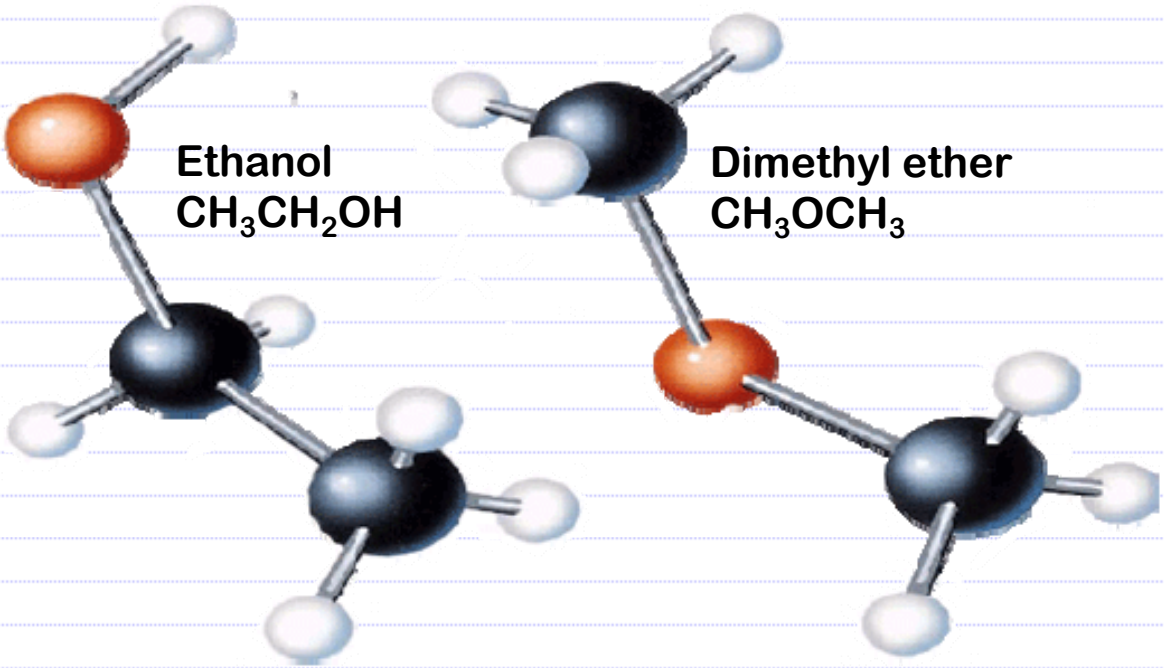
Note: See anything with respect to Molar Mass and Boiling Point?

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 electronegative of Nitrogen, Oxygen and Flourine, the resultant dipole-dipole interaction is much stronger than expected. N-H, O-H, F-H, form what we call Hydrogen Bonds.

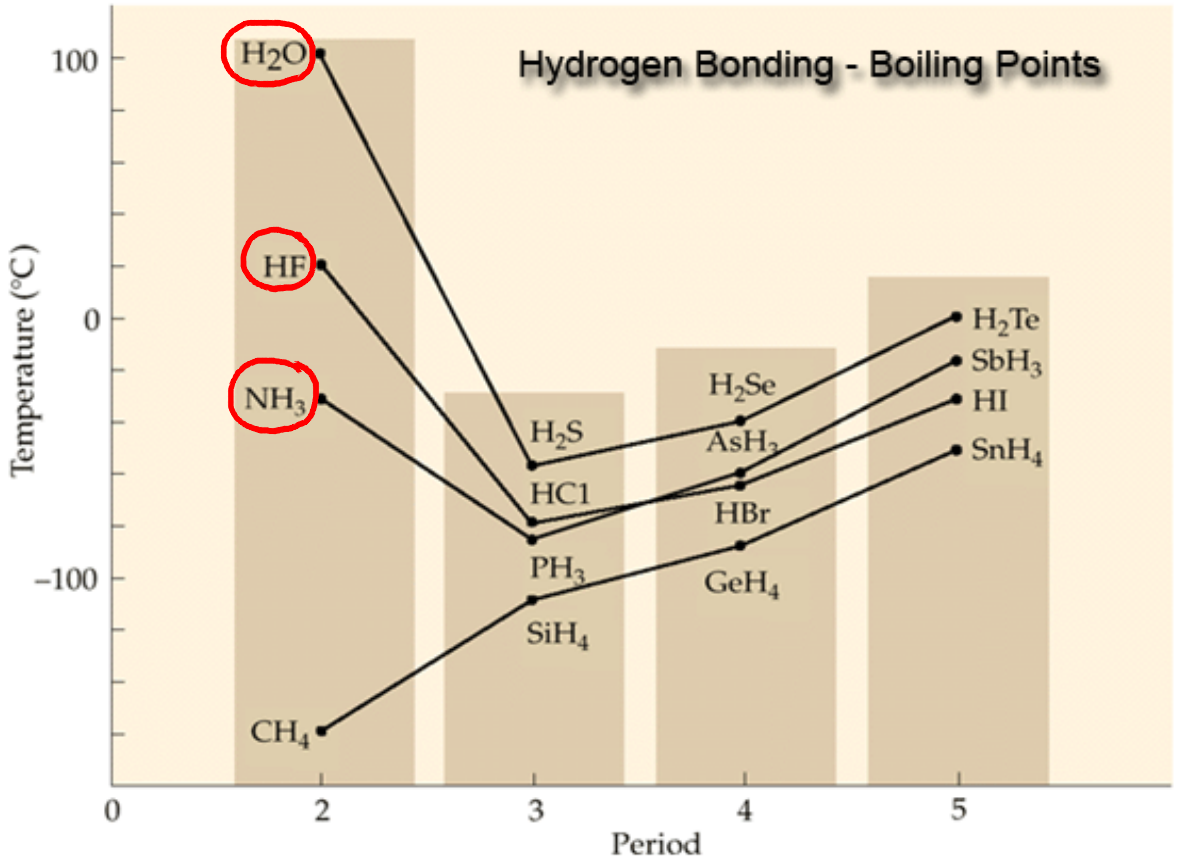


CH_3OCH_3:
Dimethyl ether, Dipole/Dipole Intermolecular Force but NO Hydrogen Bond
Boiling Point: 34.6°C

CH_3CH_2OH:
Ethanol, Dipole/Dipole Intermolecular Force with a Hydrogen Bond.
Boiling Point: 78.5°C

11.4 The Nature of Intermolecular Forces

Dipole – Dipole – A Special Case – Hydrogen Bonding



H_2Te, H_2Se, H_2S, H_2O*
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_3, AsH_3, PH_3, NH_3*
Molecular Geometry, Trigonal pyramid, all are polar. Dipole/Dipole IMF's.

SnH_4, GeH_4, SiH_4, CH_4
Molecular Geometry, tetrahedron, all are nonpolar.

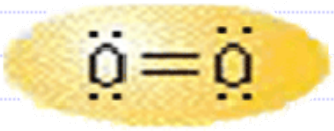
*: These three molecules contain a Hydrogen Bond.

11.4 The Nature of Intermolecular Forces

Dipole – Induced Dipole

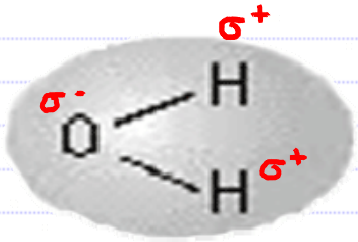
Oxygen (non-polar) dissolved in water (polar)

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



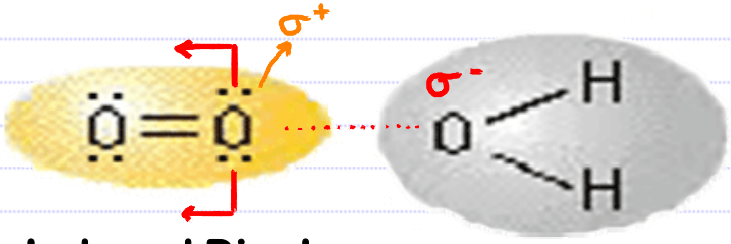
No Dipole

Nonpolar



Polar

The Solubility of Some Gases in Water		
Gas	Molar Mass	Solubility @ 20°C
	g/mol	g/100g Water
H_2	2.01	0.000160
N_2	28.0	0.000190
O_2	32.0	0.000434
Cl_2	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_2 is non-polar yet it exists as a solid?