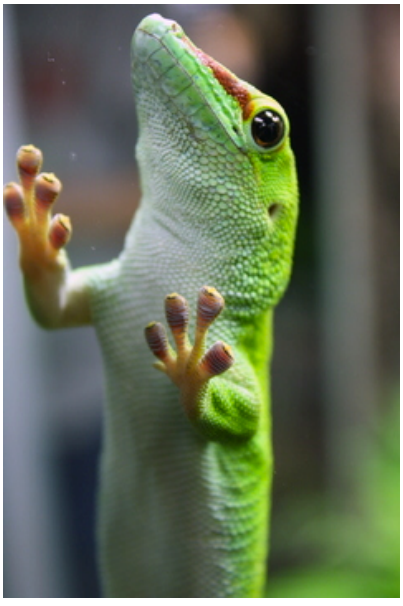
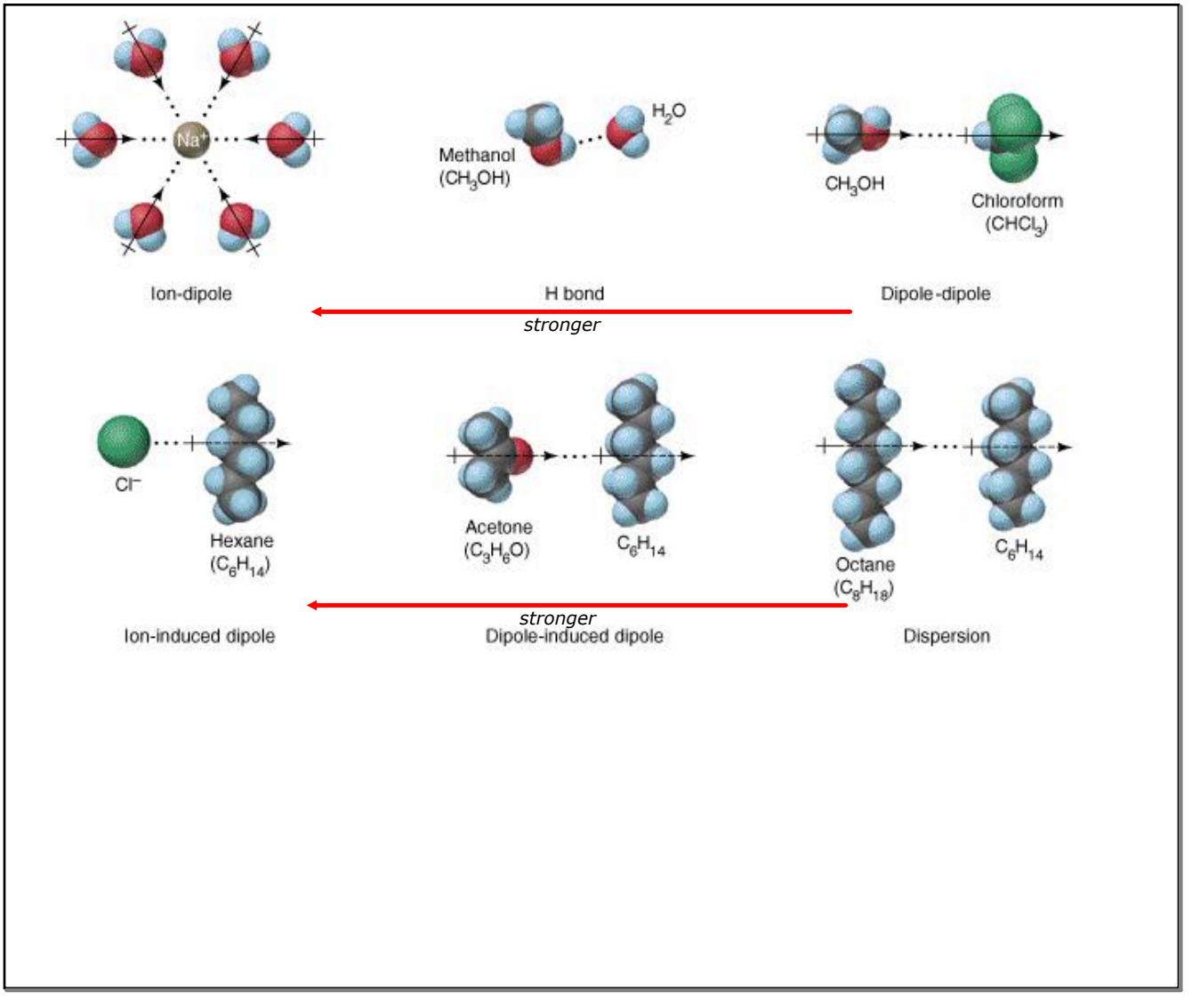
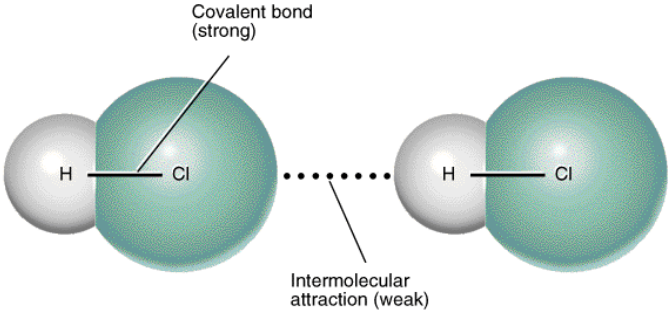
Intermolecular Forces!




Na+
Methanol
(CH3OH)
H2O
CH3OH
Chloroform
(CHCl3)
Ion-dipole
H bond
Dipole-dipole
stronger
Cl−
Hexane
(C6H14)
Acetone
(C3H6O)
C6H14
Octane
(C8H18)
C6H14
stronger
Ion-induced dipole
Dipole-induced dipole
Dispersion

The Forces between molecules (Van der Waals forces)

- All matter is held together by an electromagnetic force of attraction.
- **Intramolecular force:** forces between atoms within a molecule
  - > Ionic
  - > Polar/nonpolar covalent
  - > Metallic
- **Intermolecular force:** forces between molecules

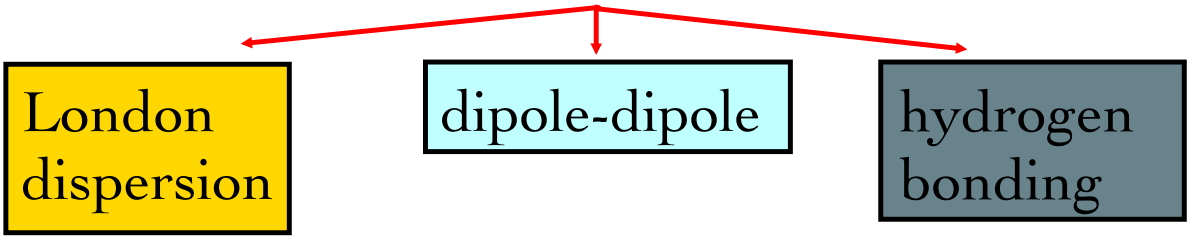


Van der Waals forces (intermolecular forces) are responsible for many properties of molecules, including:

- **melting points, boiling points**
- heats of fusion and vaporization
- surface tension, and densities.
- determines shape of gigantic molecules like enzymes, proteins, and DNA.

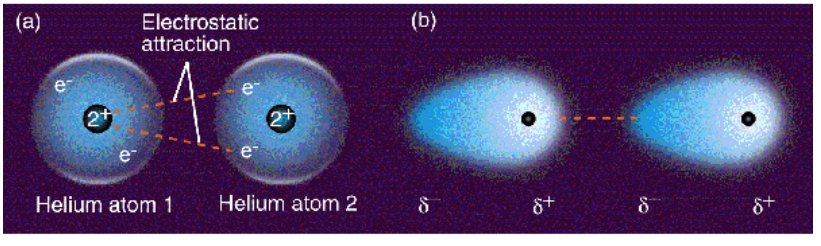
Van der Waals forces

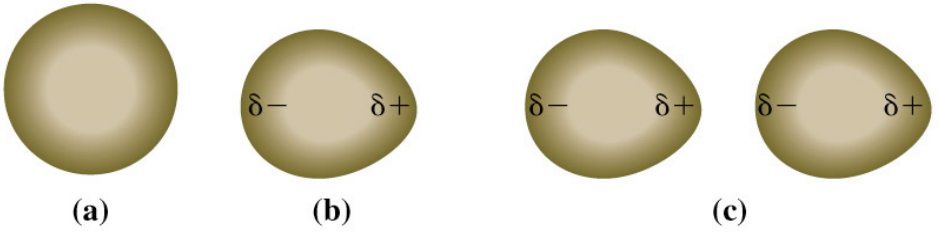
Three main categories:



- London Dispersion Forces

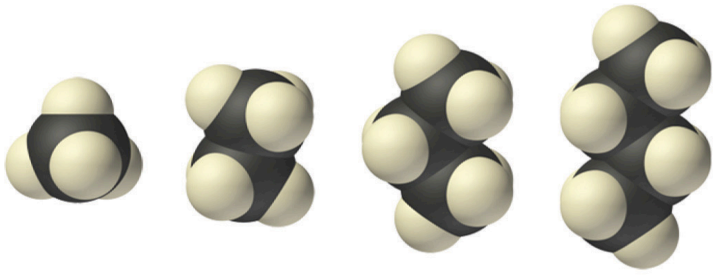
- Relatively weak force
- Results from a temporarily uneven distribution of electrons that induces a dipole in a neighbor.
- Temporary attractive force results
- London forces cause nonpolar substances to condense to liquids and to freeze into solids when the temperature is lowered sufficiently





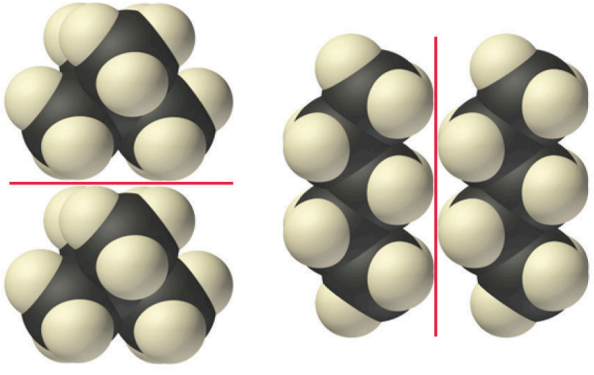
Strength of London Dispersion Force

- Strength depends on how easily electron cloud can be distorted or polarized
  - > **Bigger molecules**: electrons are farther from nucleus, easier to polarize
  - > **More surface area**: greater area where cloud can be distorted



Methane 16 g/mol −161.5°C | Ethane 30 g/mol −88.6°C | Propane 44 g/mol −42.1°C | *n*-Butane 58 g/mol −0.5°C

(a) Increasing mass and boiling point



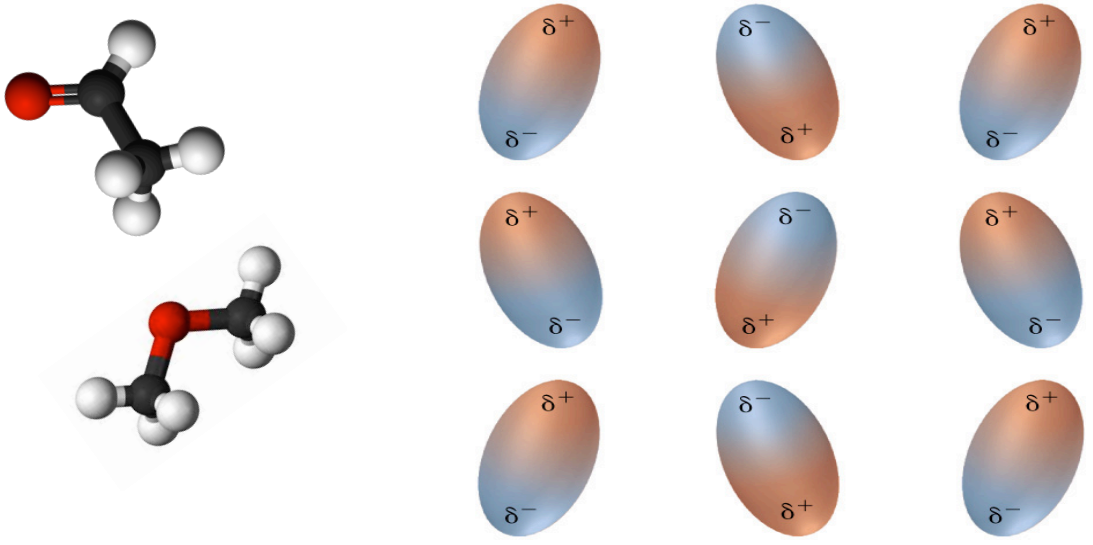
2,2-Dimethylpropane (neopentane) 72 g/mol, 9.5°C | *n*-Pentane 72 g/mol, 36.1°C

(b) Increasing surface area and boiling point

This is why CH_4 (methane) is a gas, C_6H_{14} (hexane) is a liquid, and paraffin ($C_{30}H_{62}$) is a solid at room temp.

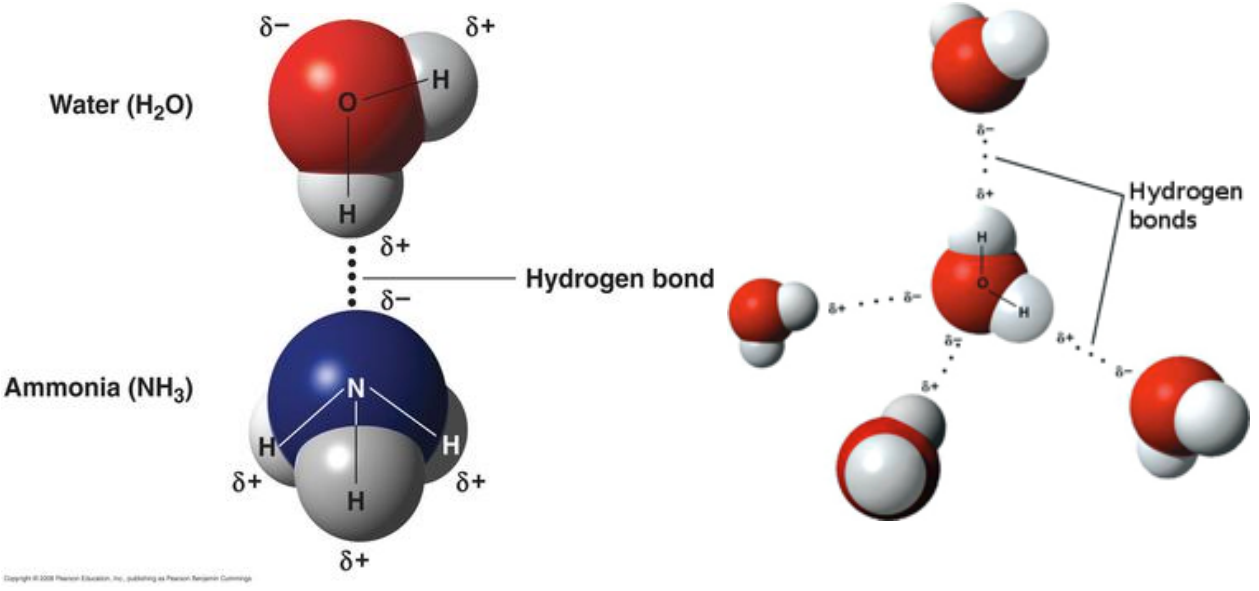
Dipole-dipole forces

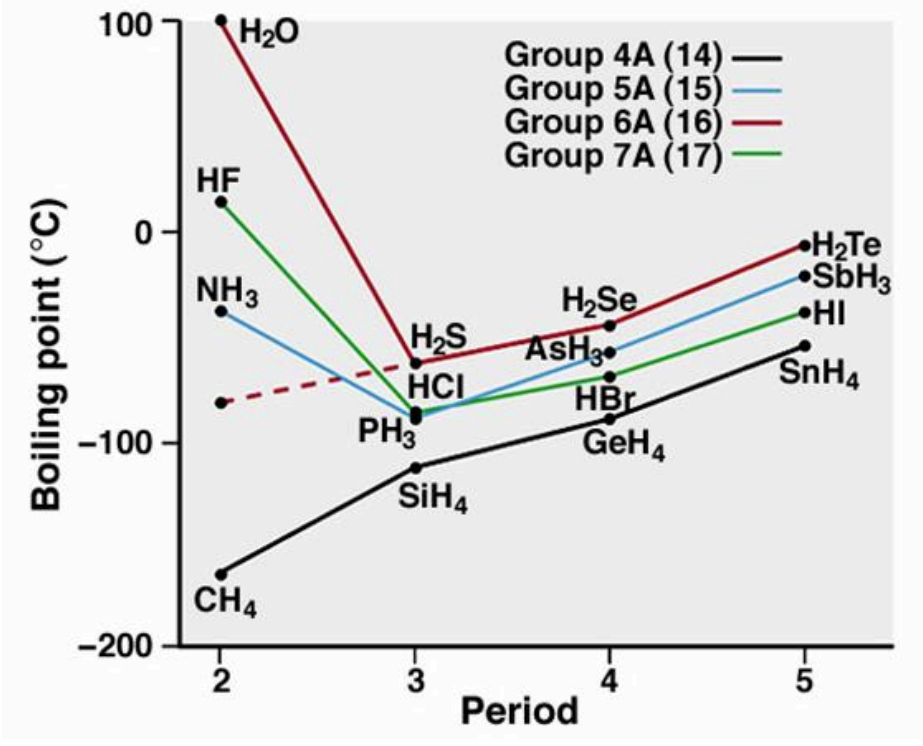
- Attractive force between positive end of one polar molecule with the negative end of another polar molecule.
- Strength increases with polarity of molecule



Hydrogen Bonding

- Particularly strong IMF
- A special case of dipole-dipole interaction where oxygen is bonded to a highly electronegative element (O, N, or F)
- Hydrogen has a partial negative charge (electron density drawn to mor electronegative atom)
- Hydrogen highly attracted to partially negative end of another molecule.




100
0
−100
−200
Boiling point (°C)
2
3
4
5
Period
Group 4A (14)
Group 5A (15)
Group 6A (16)
Group 7A (17)
H2O
HF
NH3
CH4
H2S
HCl
PH3
SiH4
H2Se
AsH3
HBr
GeH4
H2Te
SbH3
HI
SnH4

Hydrogen Bonding Video

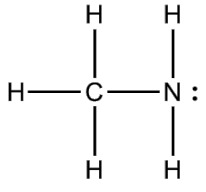
Strength of intermolecular force of equal size particles

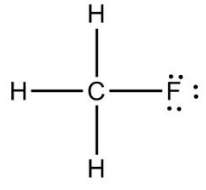
- Hydrogen bonds (strongest)
- Dipole-dipole attraction
- London dispersion forces (Weakest)

For each substance, identify the key bonding and/or intermolecular force(s), and predict which one of the pair has the higher boiling point.

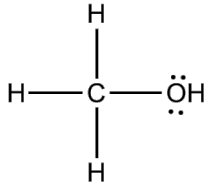
a) $MgCl_2$ or PCl_3

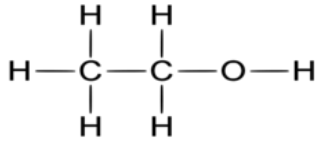
b) CH_3NH_2 or CH_3F





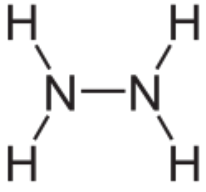
c) CH_3OH or CH_3CH_2OH

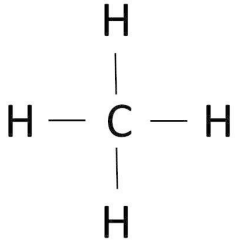


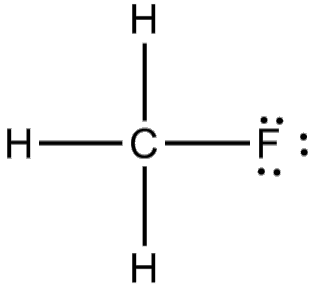


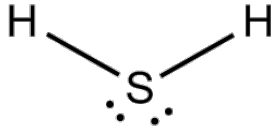
d) Ne or Kr

Which substance will show hydrogen bonding?









List the substances in order of increasing boiling points.

H_2 CO HF

Ne $BaCl_2$

Identify the type of intermolecular attraction for each substance.

NH_3 Kr C_6H_6 SO_2 CH_3OH

*Lets think back to Lab 4...

Why do ionic compounds have very HIGH melting points compared to covalent compounds?

*Quick lesson on lewis structures of covalent compounds...

Carbon is usually a chain (connected to each other)

Formula will indicate to you which "parts" connect to each other.

December 18, 2014