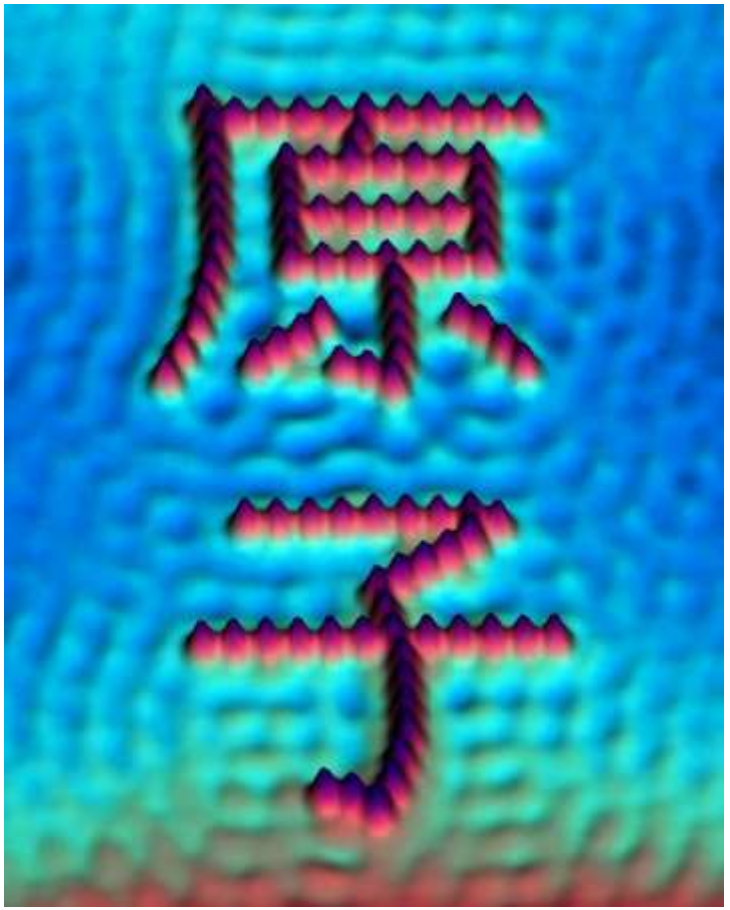
Pre-AP Chemistry

September 4, 2011

18. Intermolecular Forces



Review

Draw the Lewis structures for

$MgCl_2$ Xe CH_2Cl_2

CH_2O H_2O

What is the polarity of each bond in the molecules above?

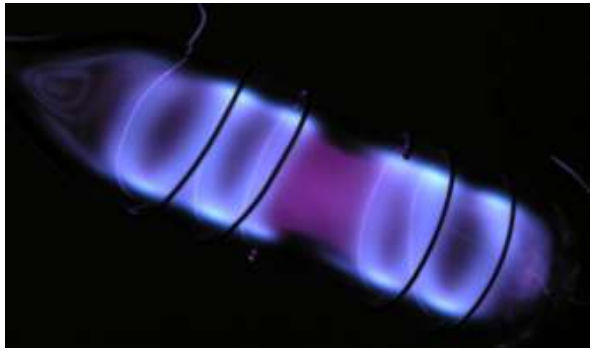
What is the polarity of the overall molecule?

Review

Why do compounds have different phases?

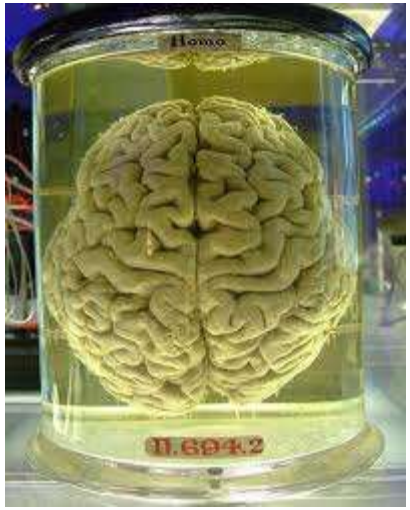
$MgCl_2$

Xe



HF

CH_2O



H_2O

Outline

- Absolute Zero
- Intermolecular Forces
- Turning up the heat …

- 0 K
- Intermolecular Forces
  - Dipole-Dipole Forces
  - Hydrogen Bonding
  - London Dispersion (van der Waals) Forces
- Turning up the heat …

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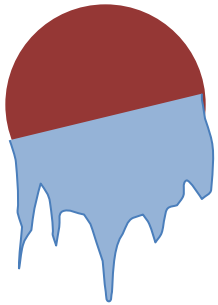
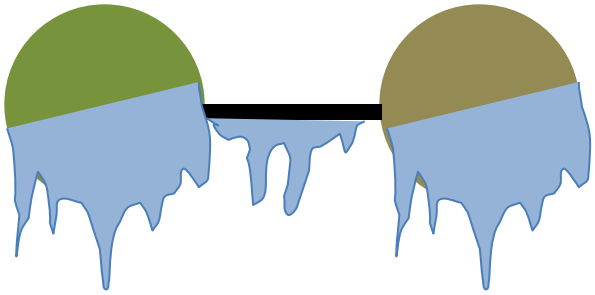
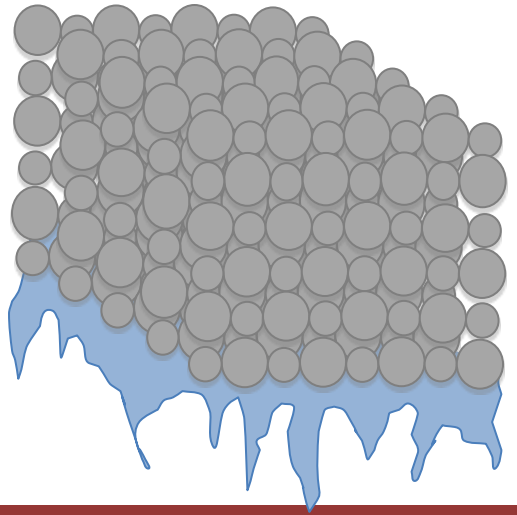
Absolute Zero

- Absolute Zero = 0 K = coldest possible temperature
- All atoms are in their ground state
- Molecules are ‘frozen’
- Almost all matter is solid

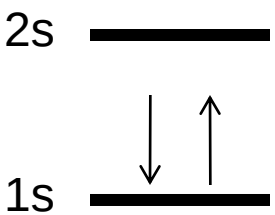


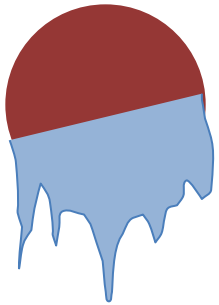




Absolute Zero

- What happens when we raise the temperature … ?





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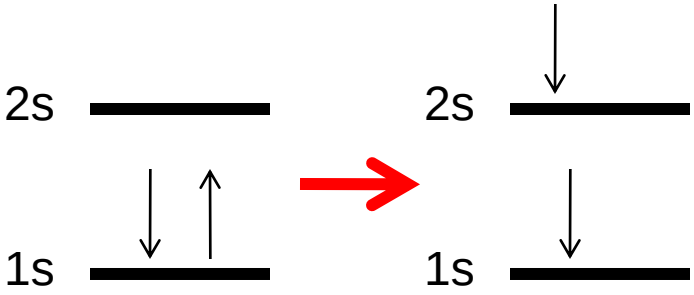

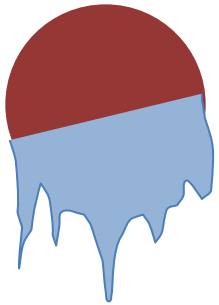

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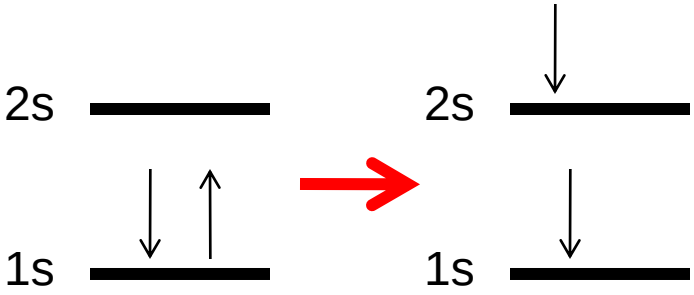

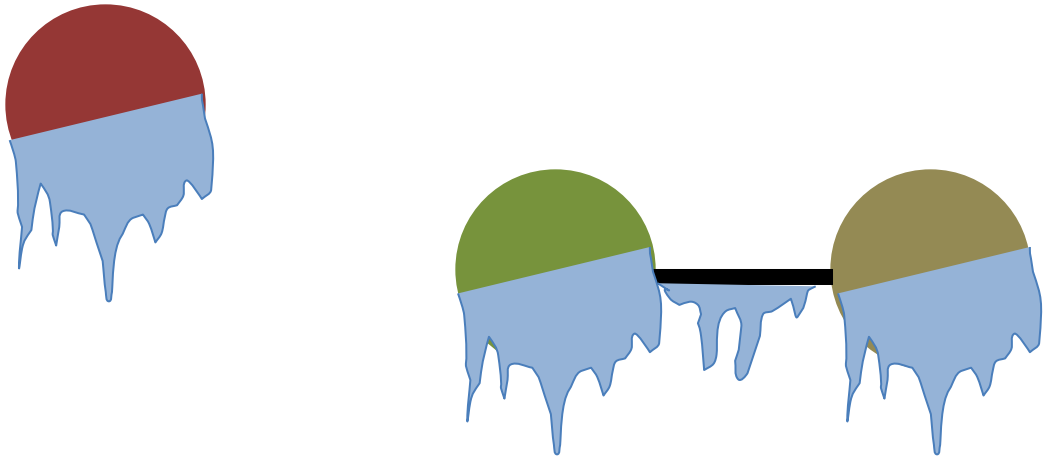

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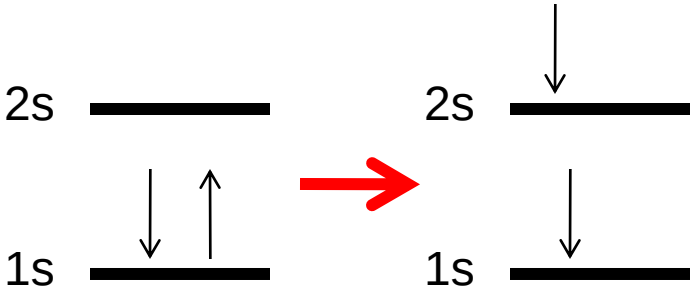

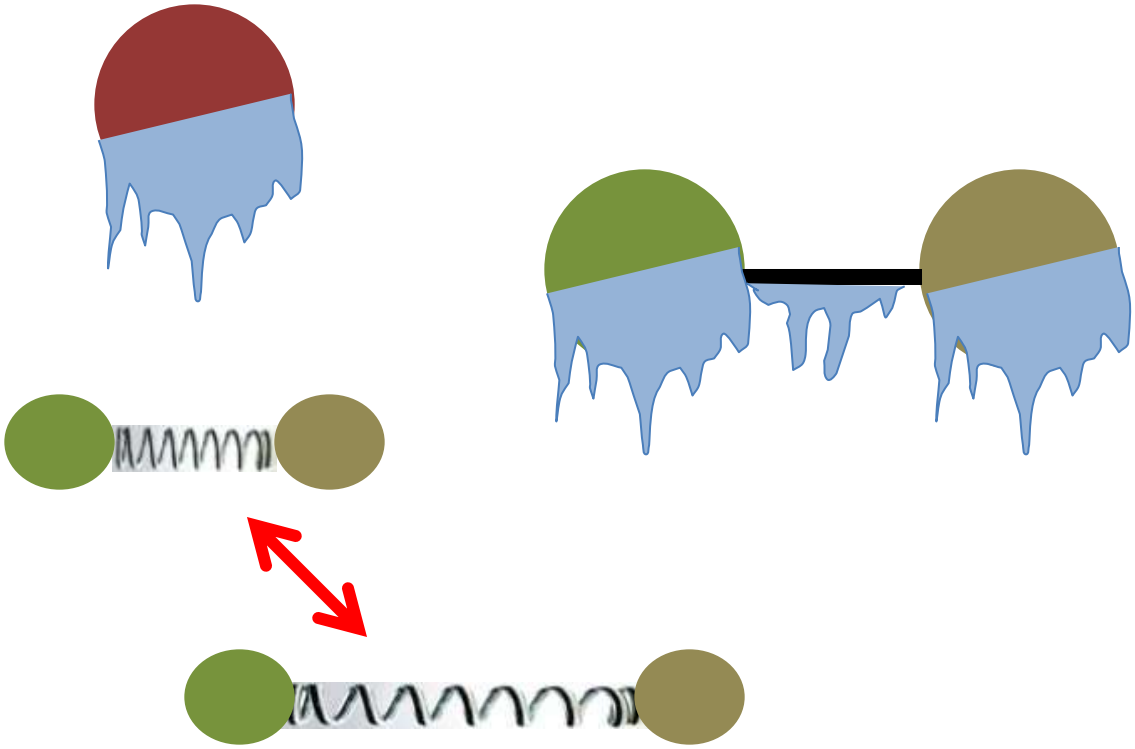

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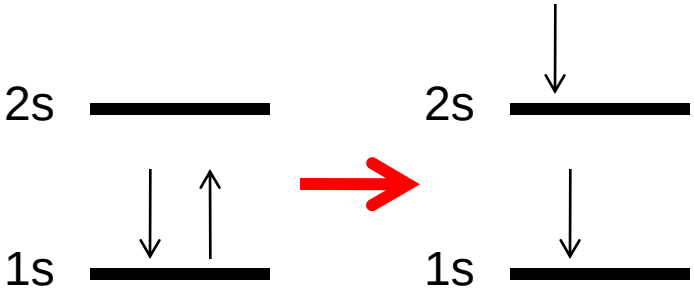

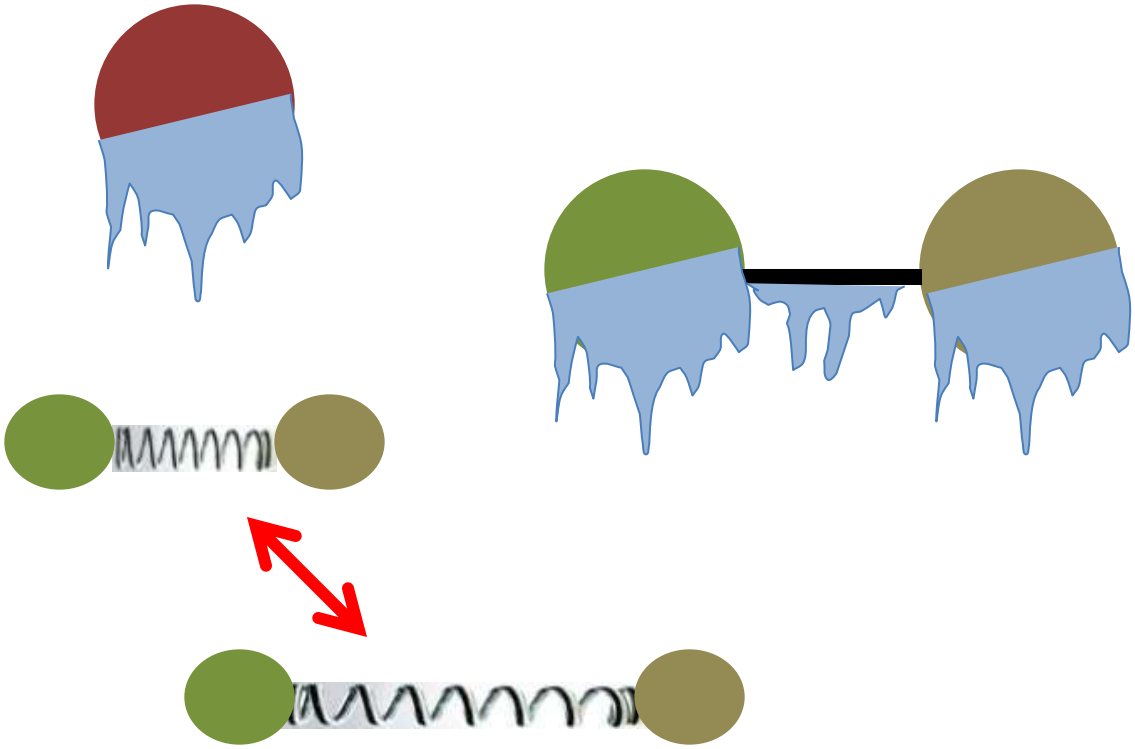

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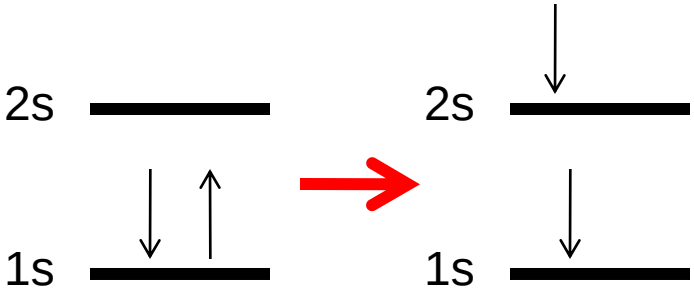
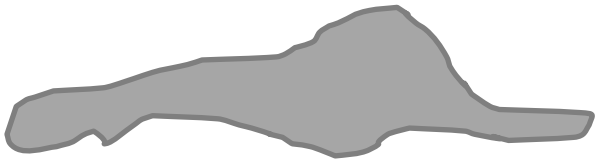
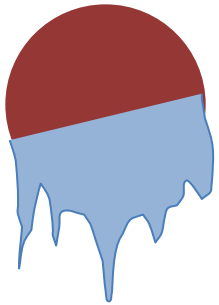
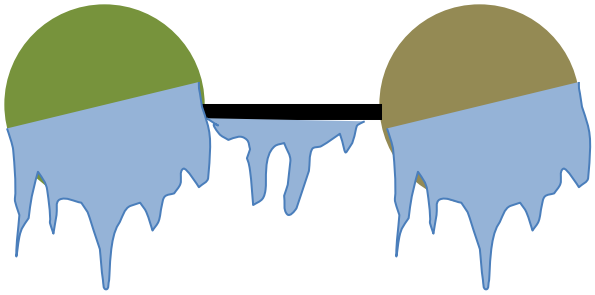
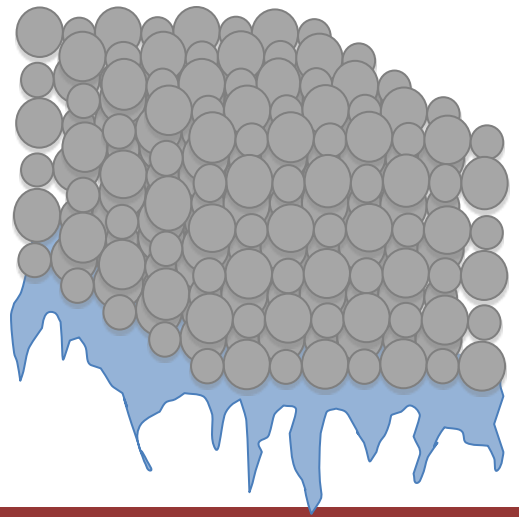
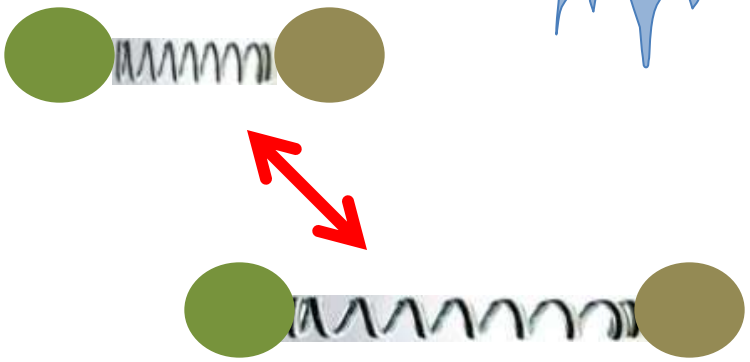






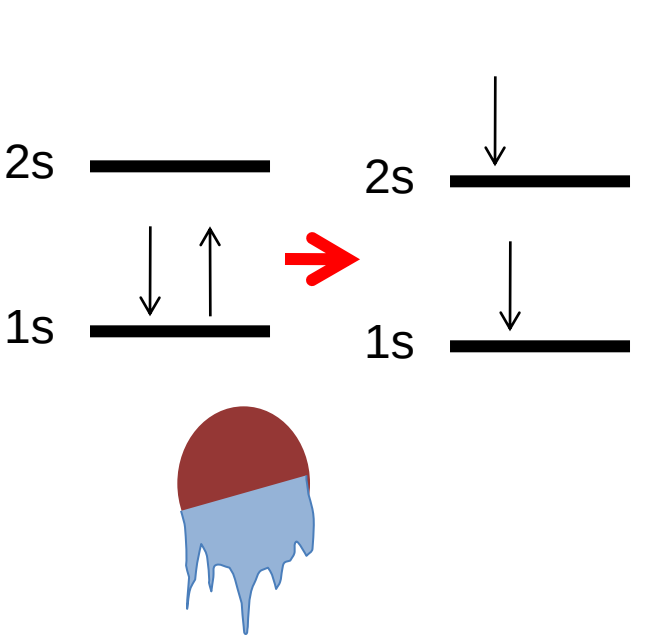


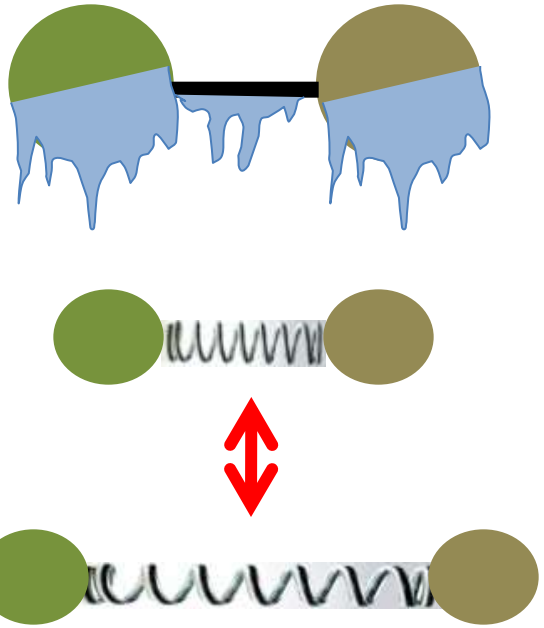


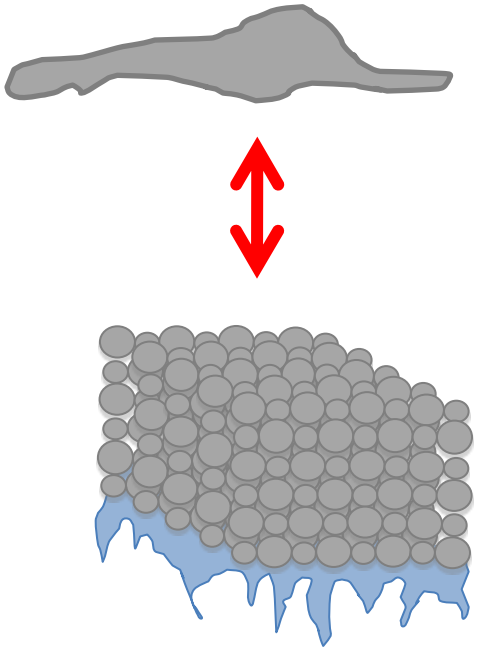


Absolute Zero

- We know about ground- and excited-states of atoms
- We'll talk about molecular vibrations later (next semester)
- What about phase changes?







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- Intermolecular Forces
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  - Dipole-Dipole Forces
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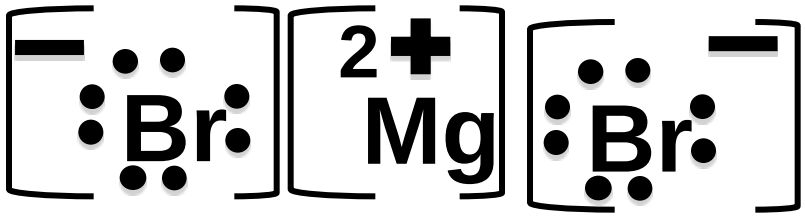
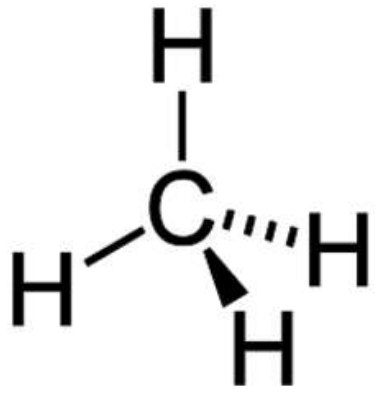
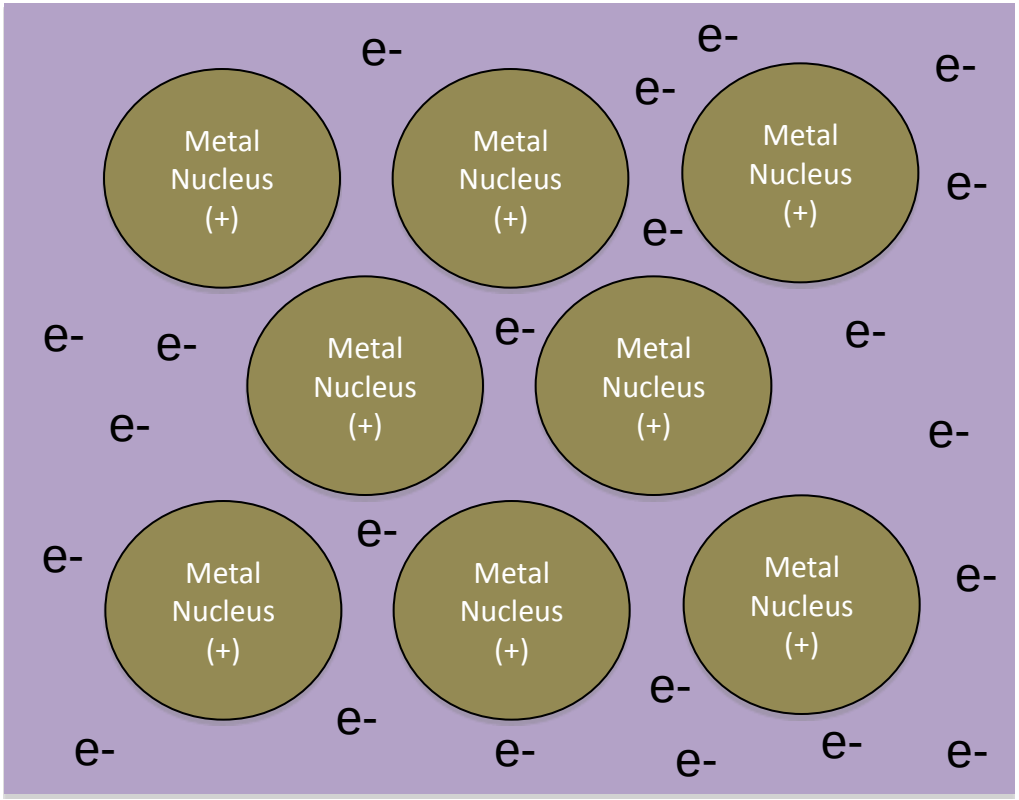
Intramolecular Forces

- Intramolecular forces = forces between atoms in the same molecule
- Intramolecular forces = bonds (ionic, covalent, metallic)

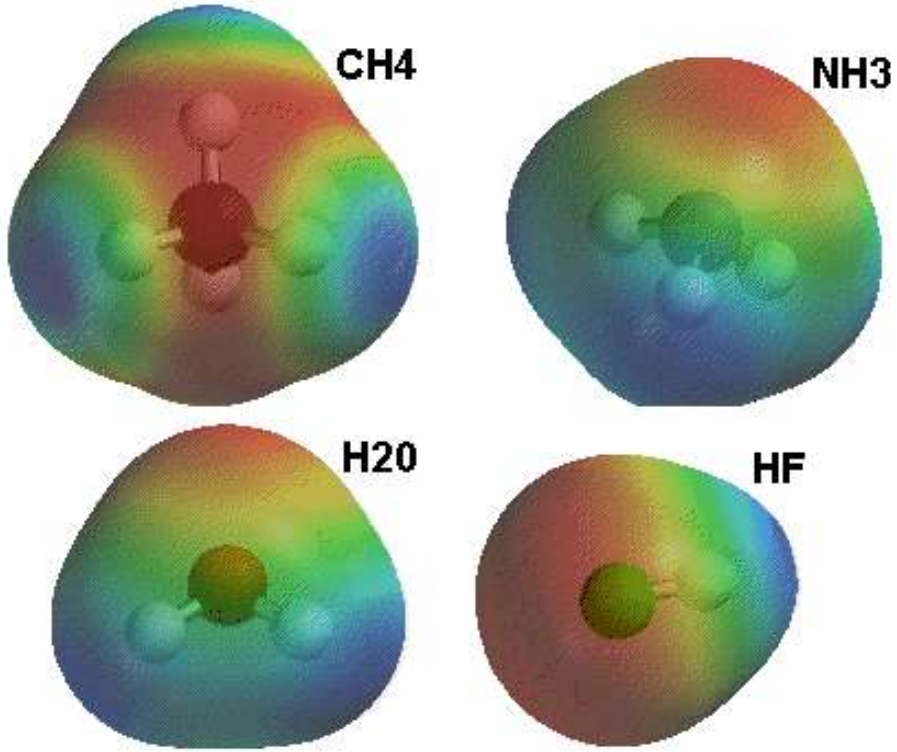






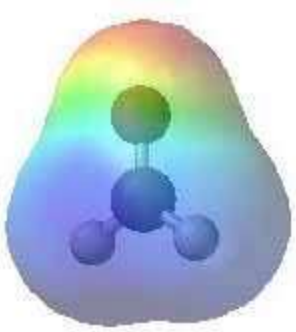
Intermolecular Forces

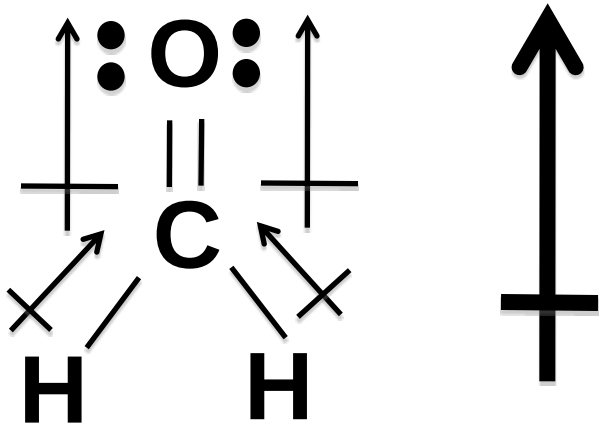
- Intermolecular forces = forces between atoms in different molecules
- Come from either permanent or temporary charges on atoms



Dipole-Dipole Forces

- Dipole = separation of opposite charges
- Polar molecules are molecular dipoles
- Partially charged atoms on one molecule attract (repel) atoms with opposite (same) partial charges on another molecule





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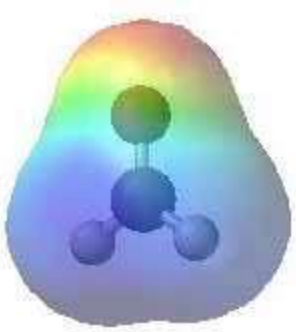

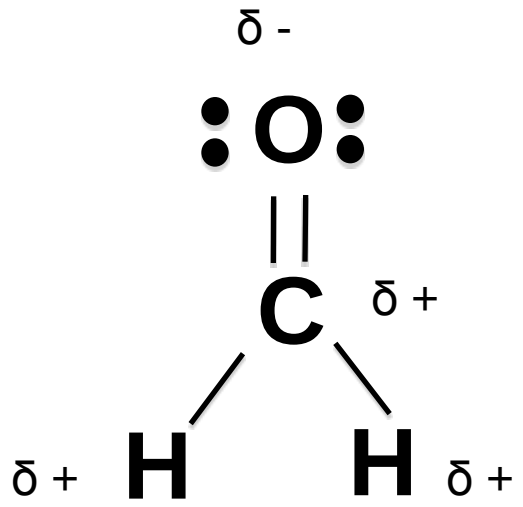

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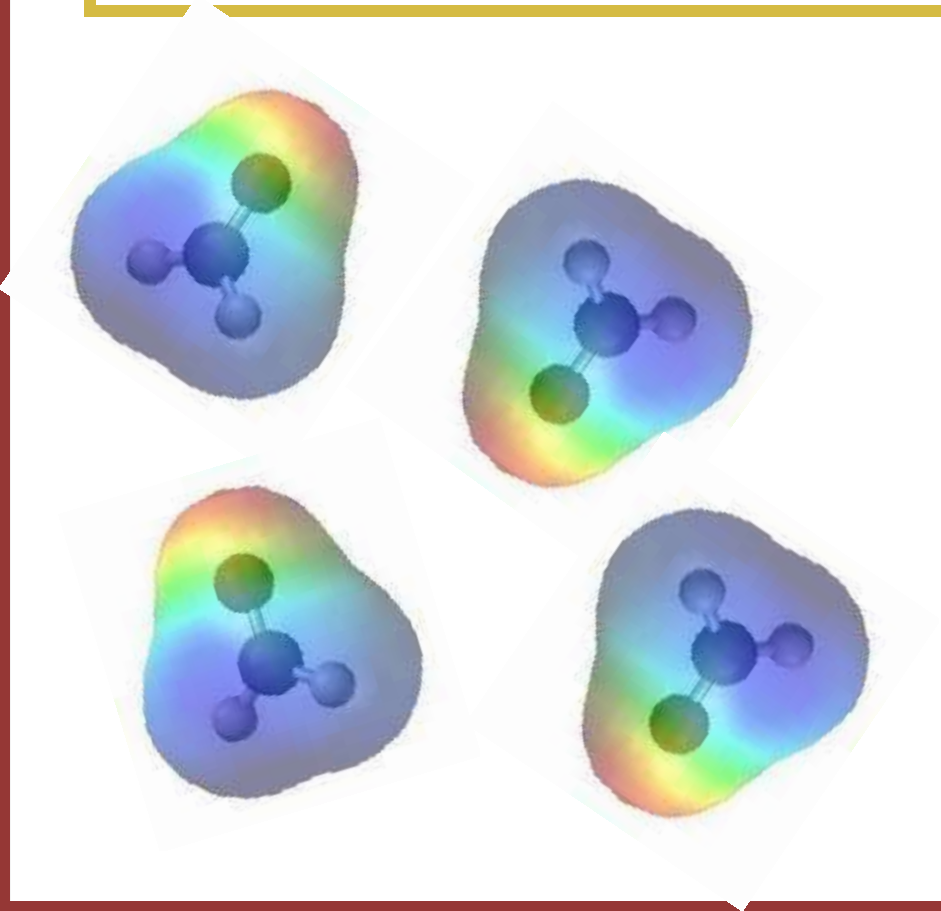
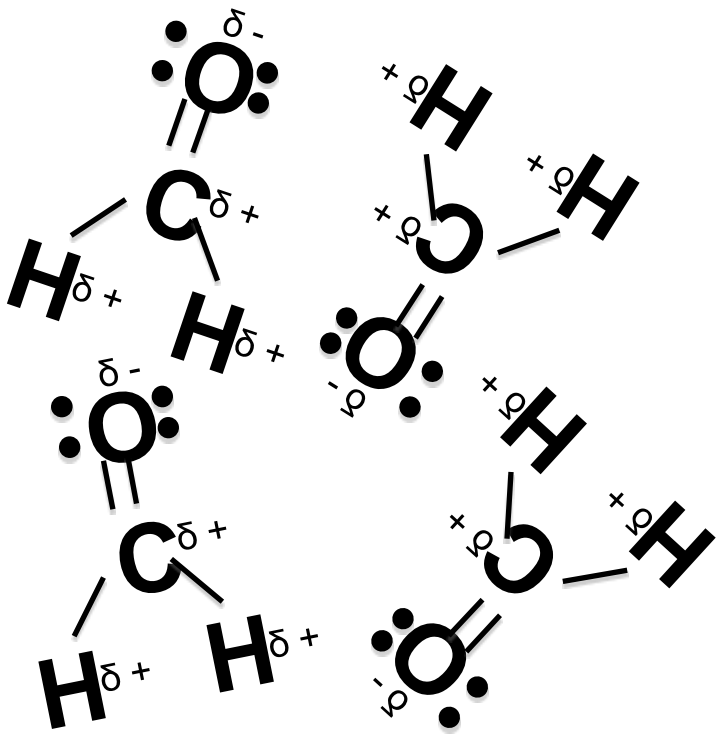
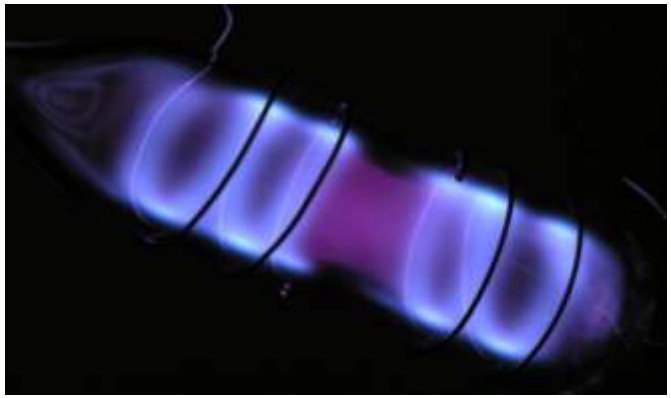




Mini-Quiz

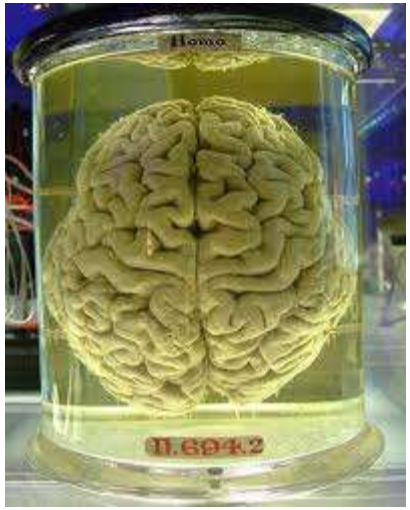
Which compounds below have the greatest dipole-dipole interactions?

Xe



H_2O

CH_2O



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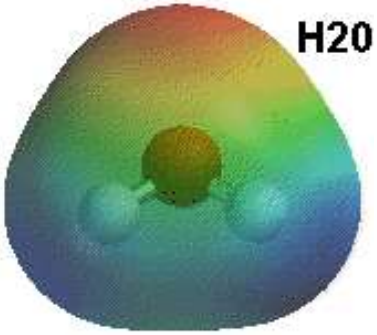
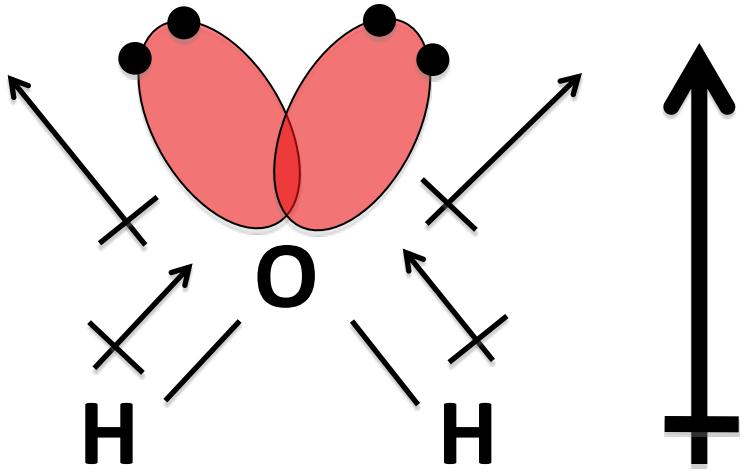
Hydrogen Bonding

- H = very weakly electronegative = often has partial positive charge when bonded to another atom
- Hydrogen bond = special dipole-dipole interaction between H bonded to N, O, F, or Cl in one molecule and another N, O, F, or Cl on a different molecule





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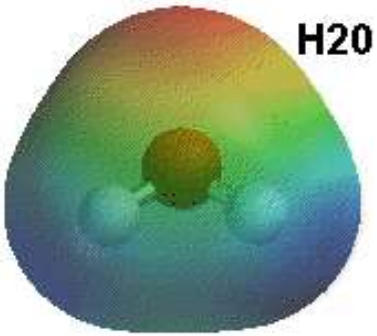

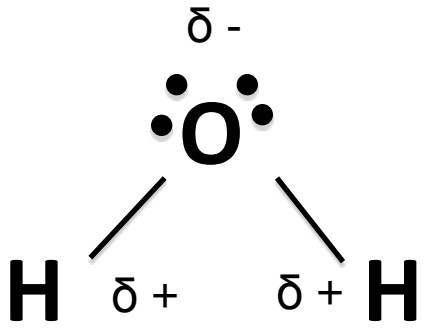

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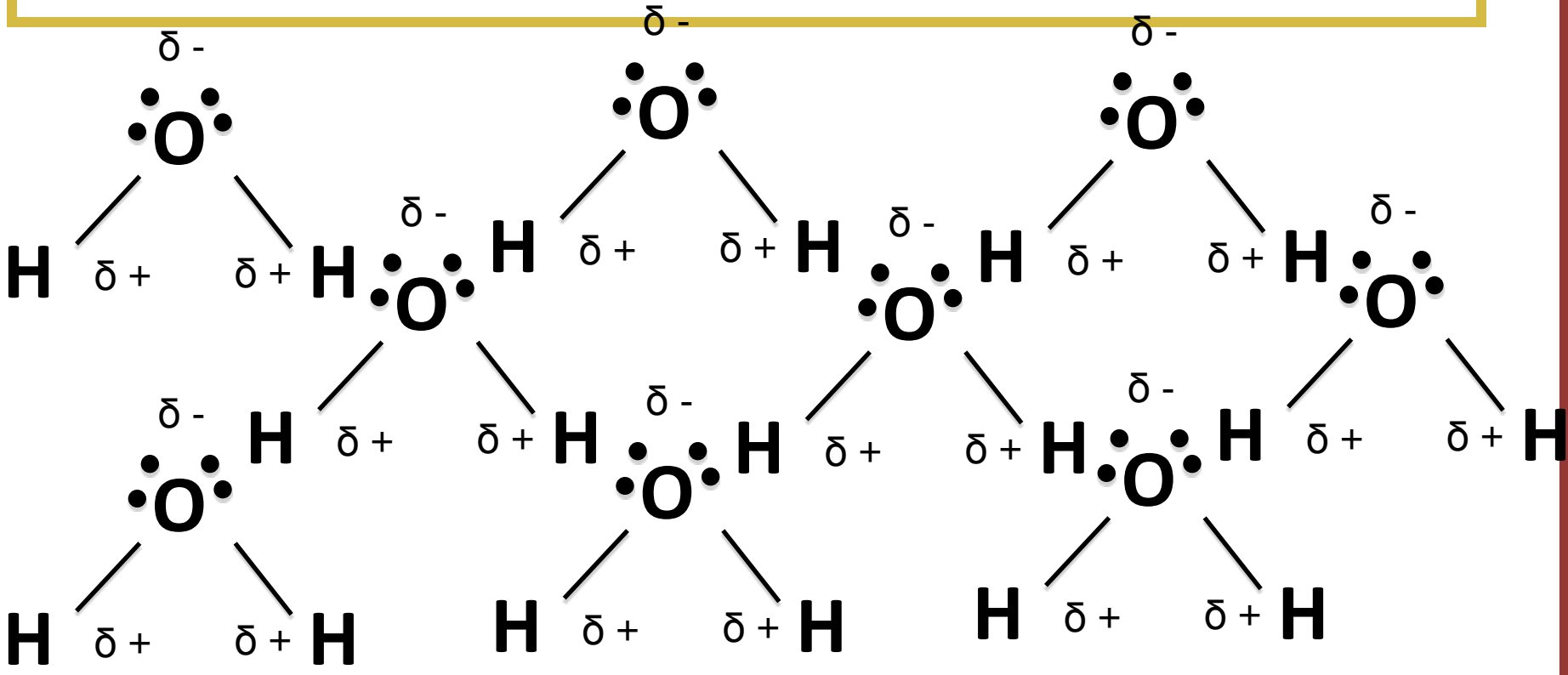
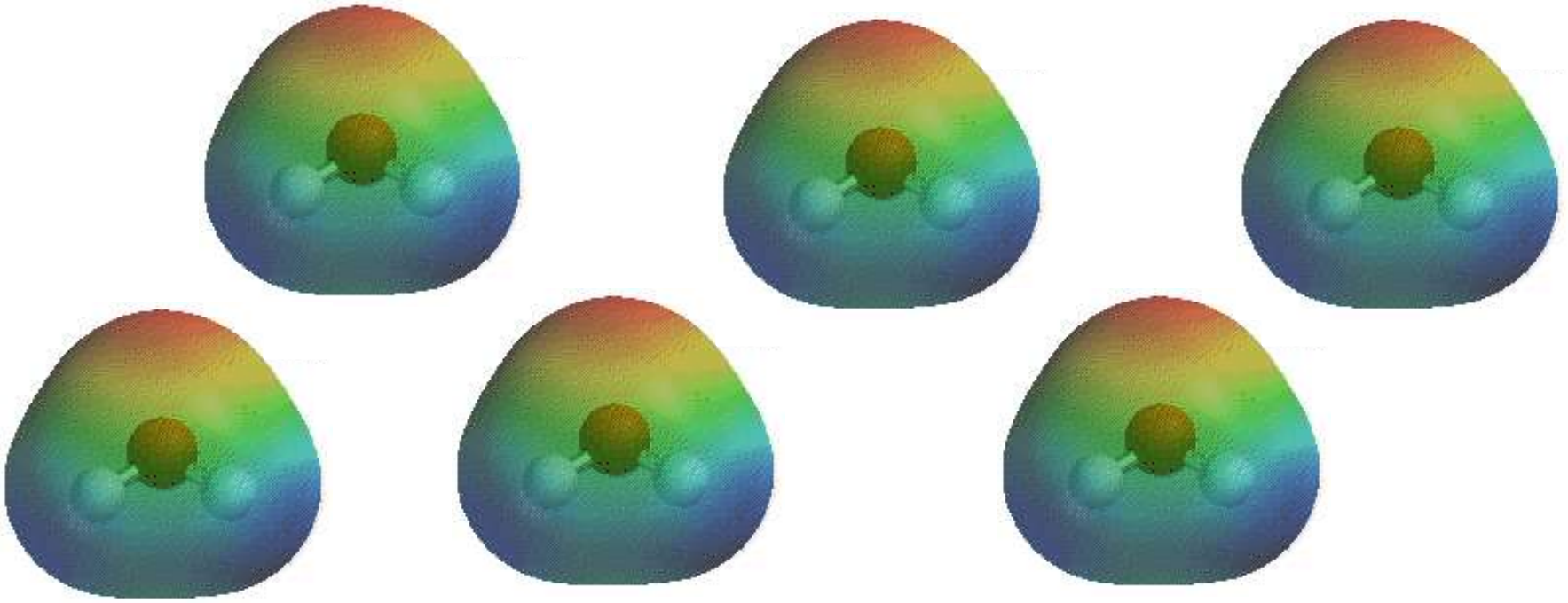


Hydrogen Bonding

- Hydrogen bonds often form large networks of strong intermolecular forces
- This makes hydrogen bonds extremely strong dipole-dipole forces



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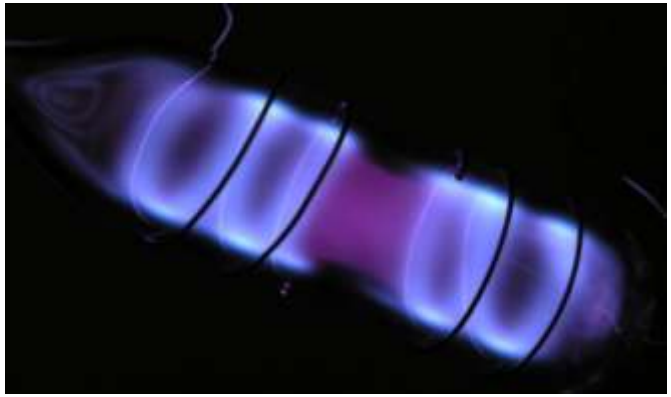

H_2O

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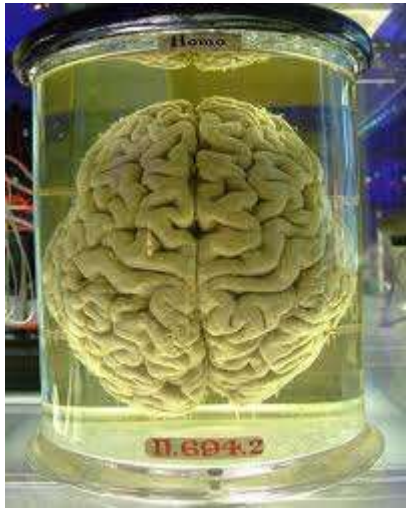

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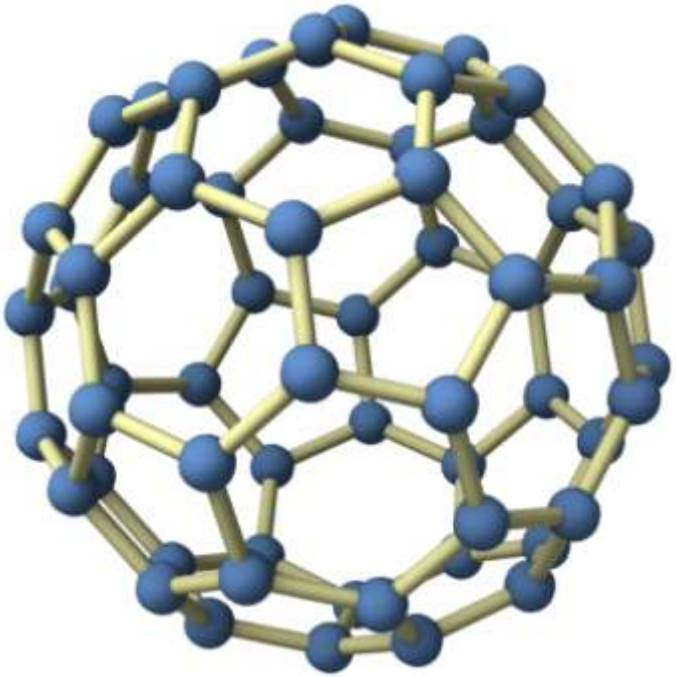
London Dispersion Forces

- Also called ‘van der Waals’ forces
- Weak intermolecular forces caused by instantaneous, temporary molecular dipoles
- Exist in all molecules



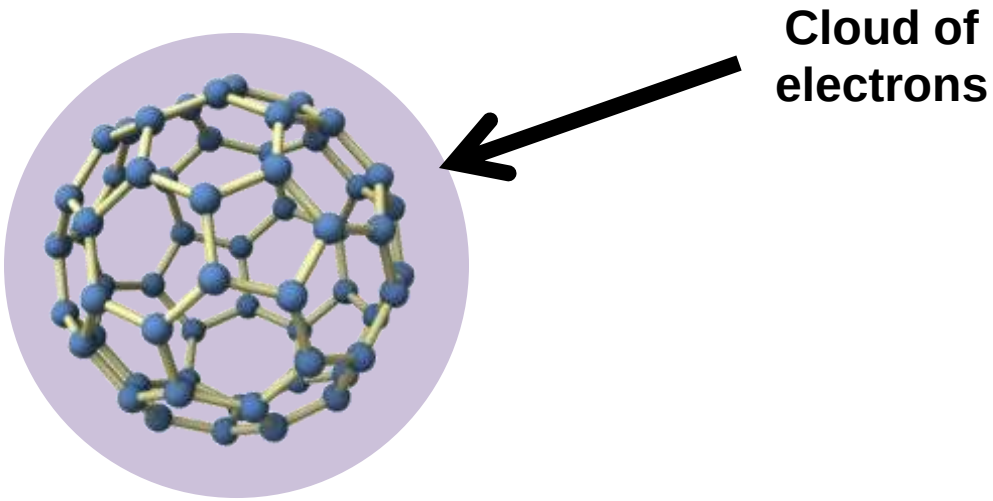
C_{60}

Xe

Single atoms and pure elements have no permanent dipole moment!

London Dispersion Forces

- Electrons are in constant, random motion around nucleus
- The random motion sometimes results in small, short-lived dipoles even on non-polar molecules



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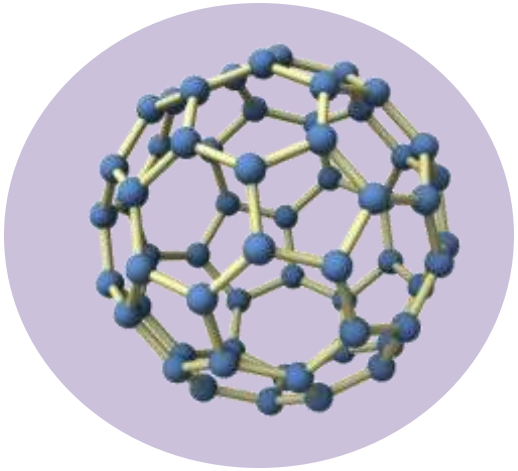

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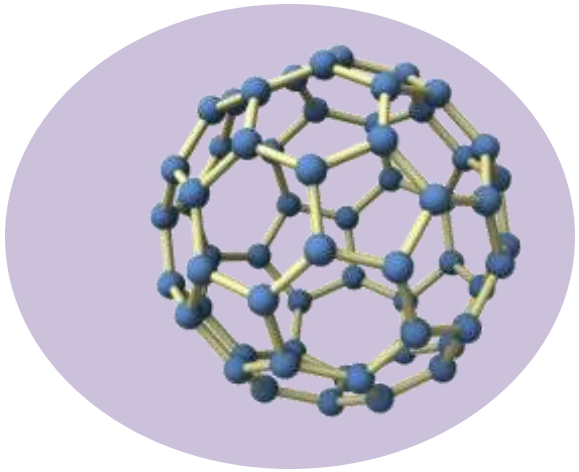

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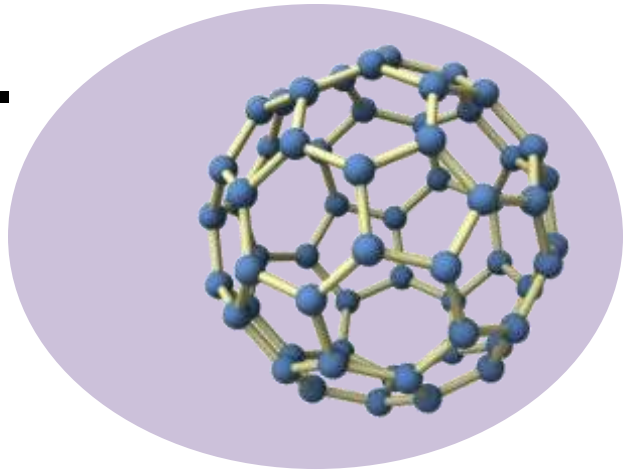
δ-



δ+

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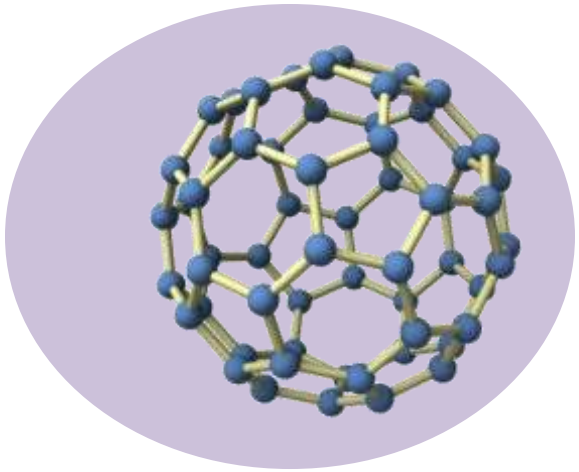

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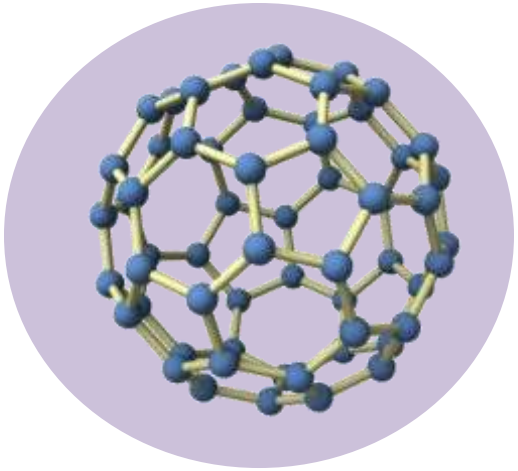

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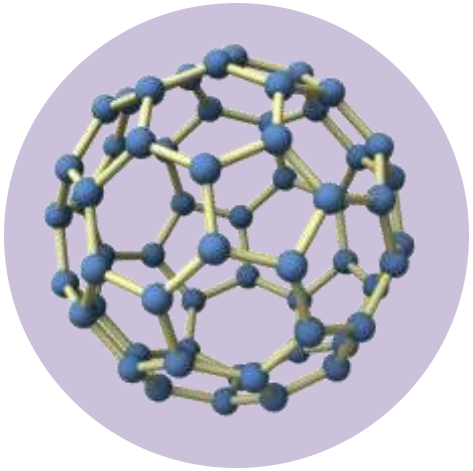

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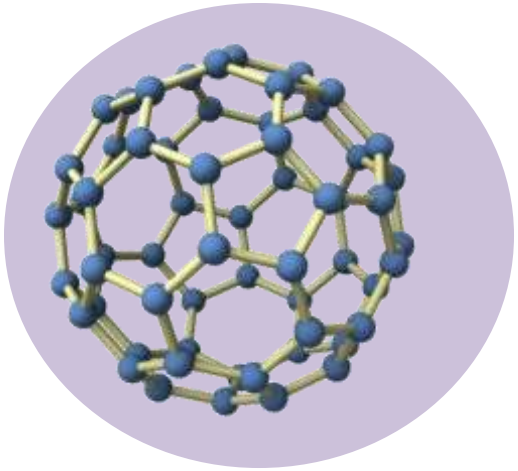

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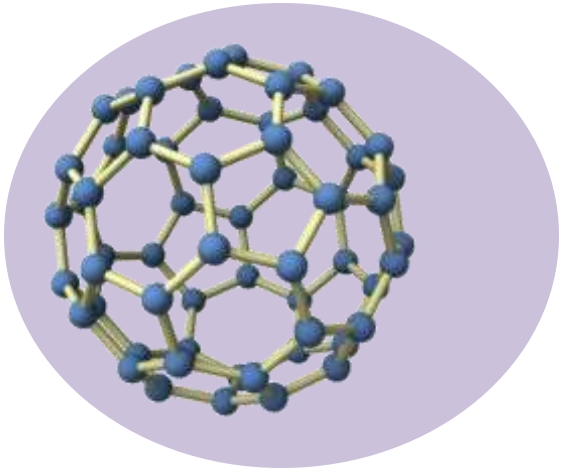

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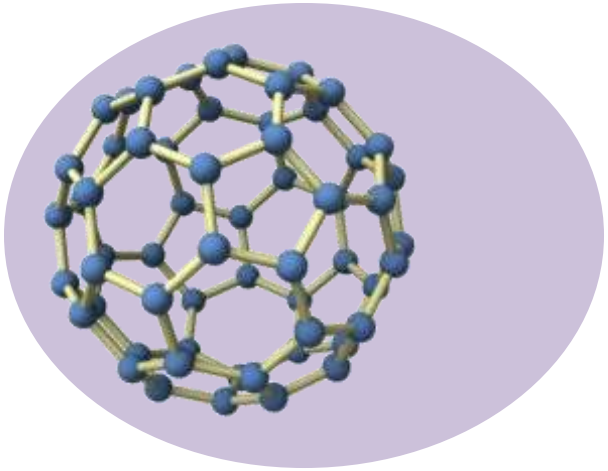

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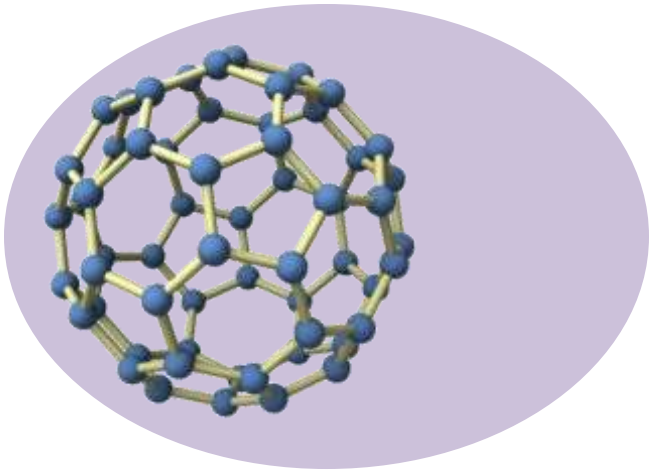
δ+  δ-

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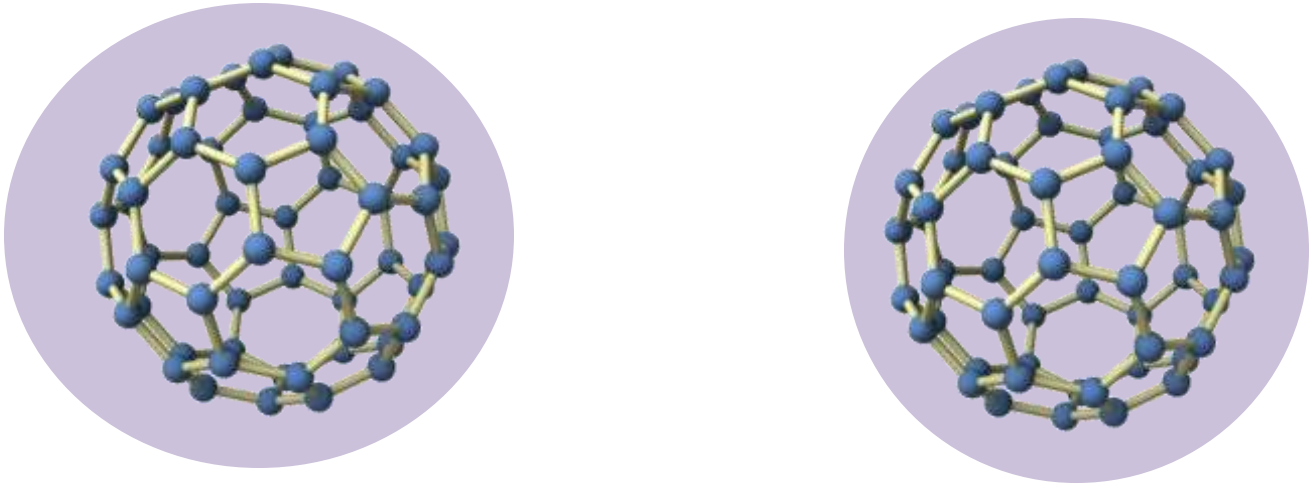
- London dispersion forces result from many, many instantaneous, induced dipoles



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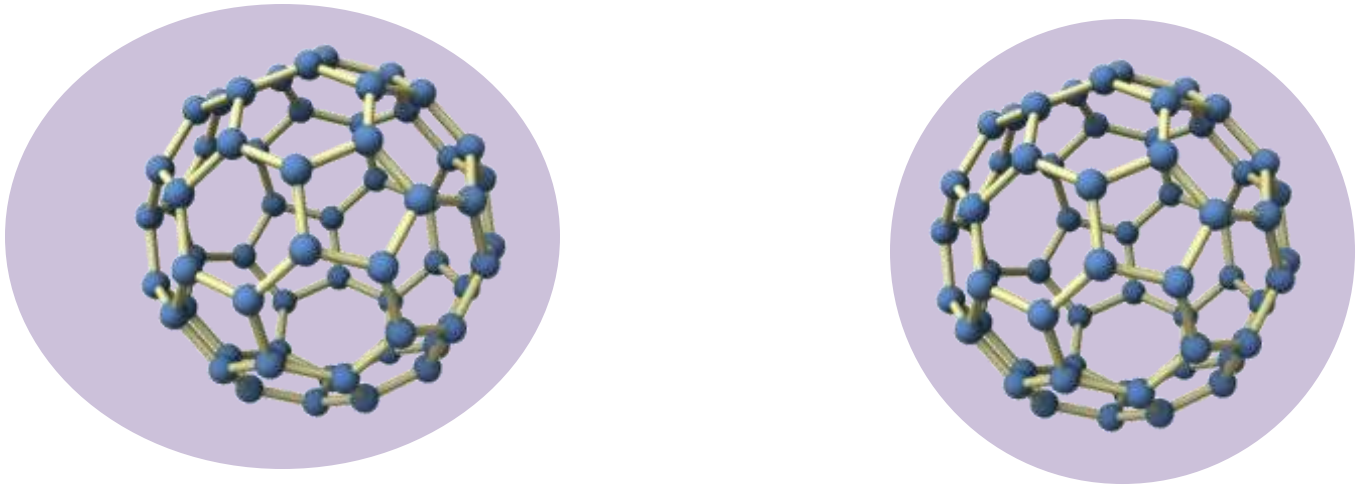

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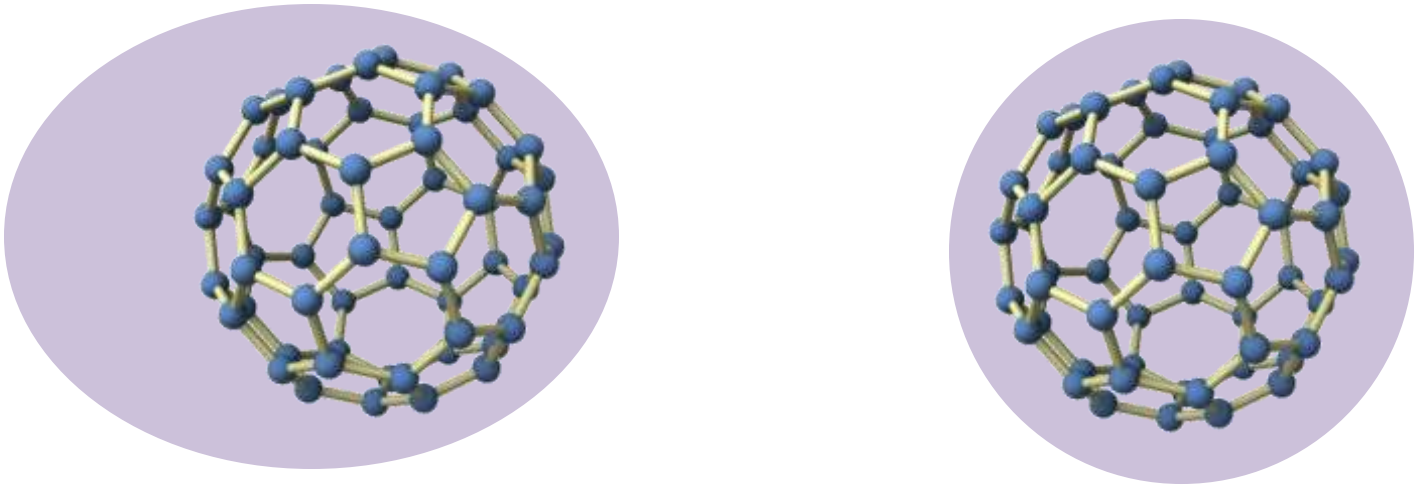

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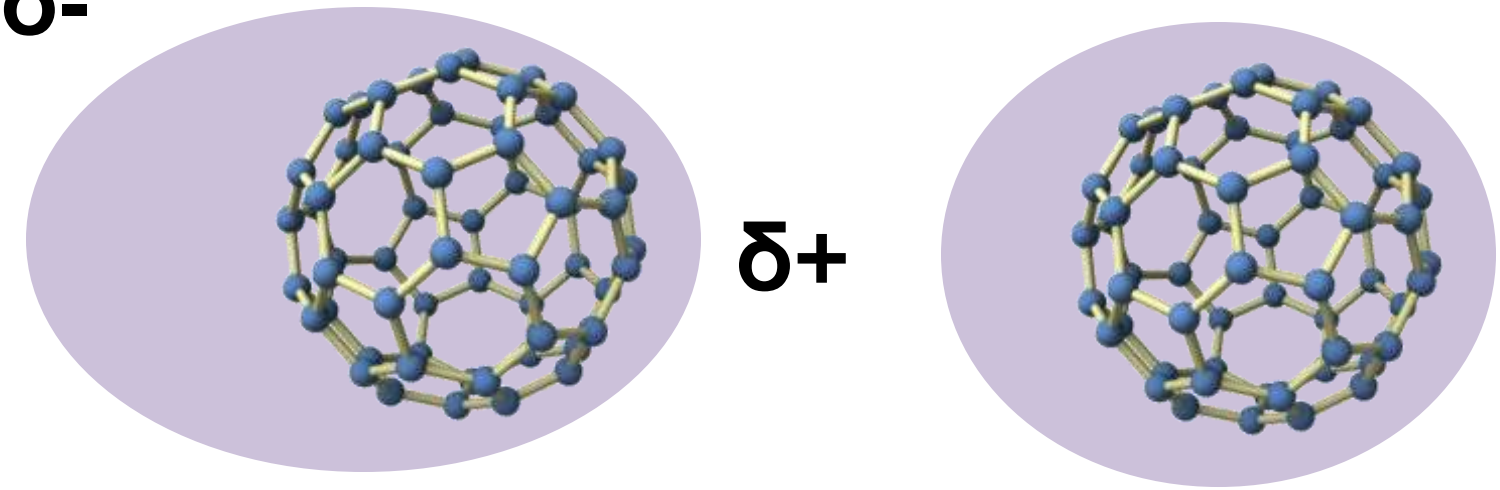

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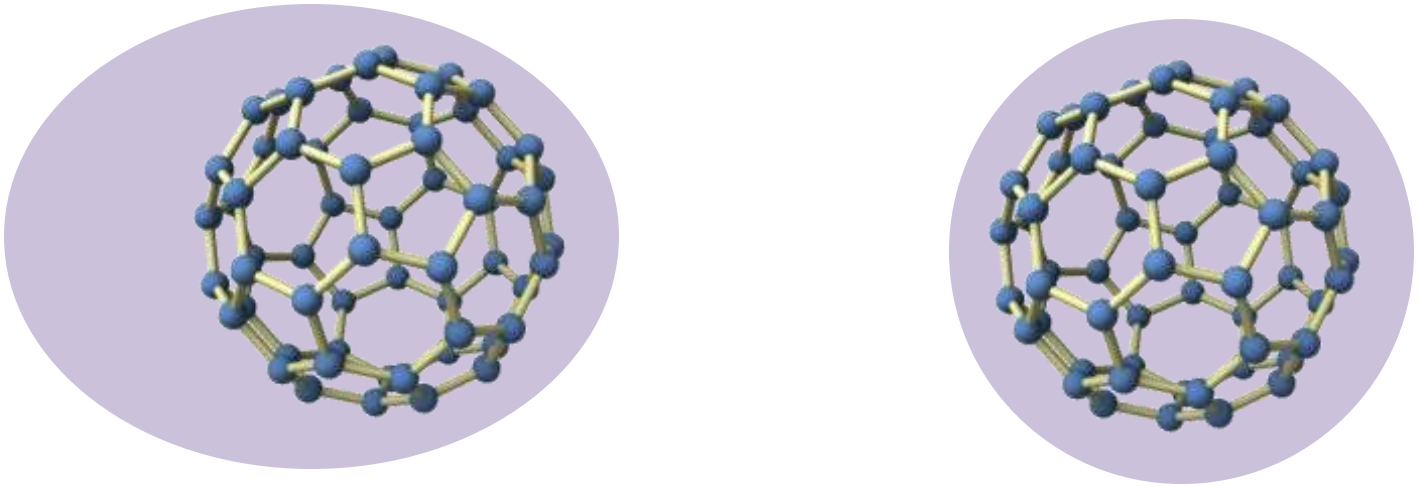

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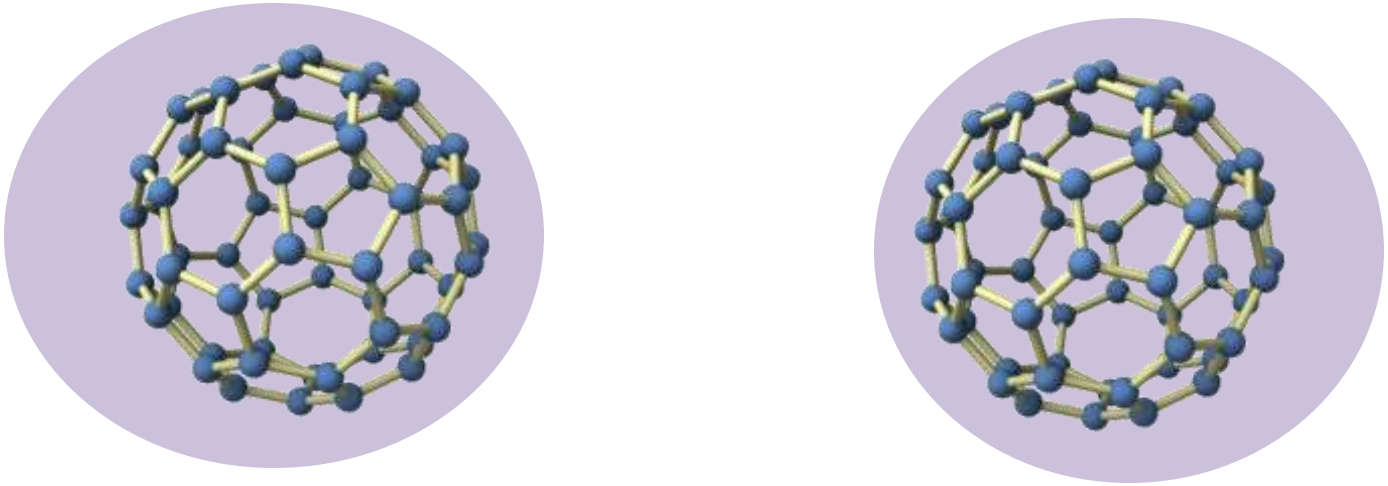

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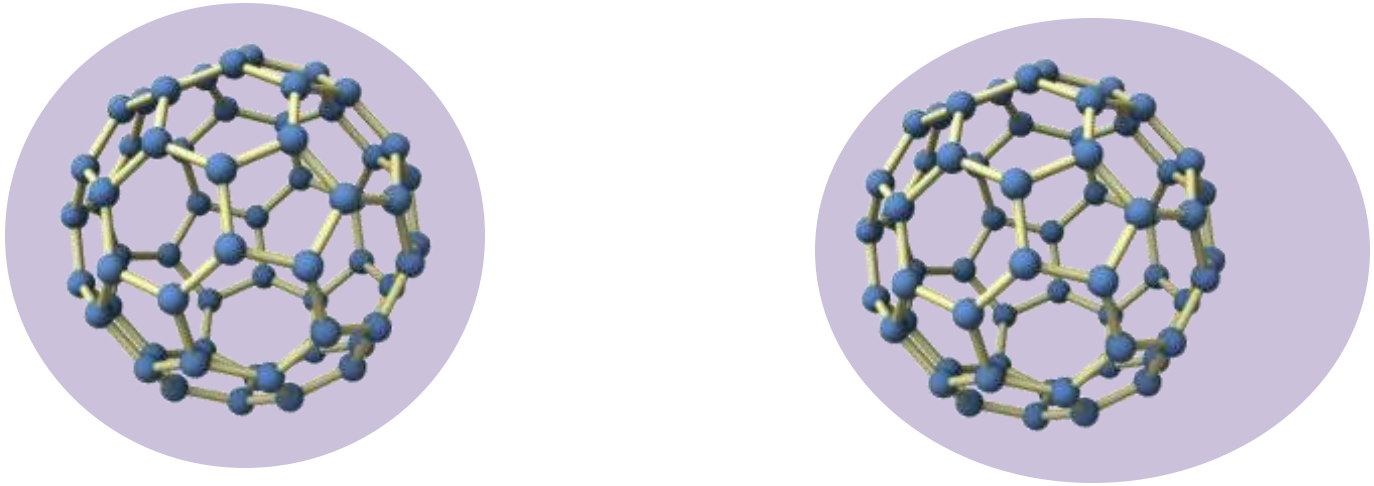

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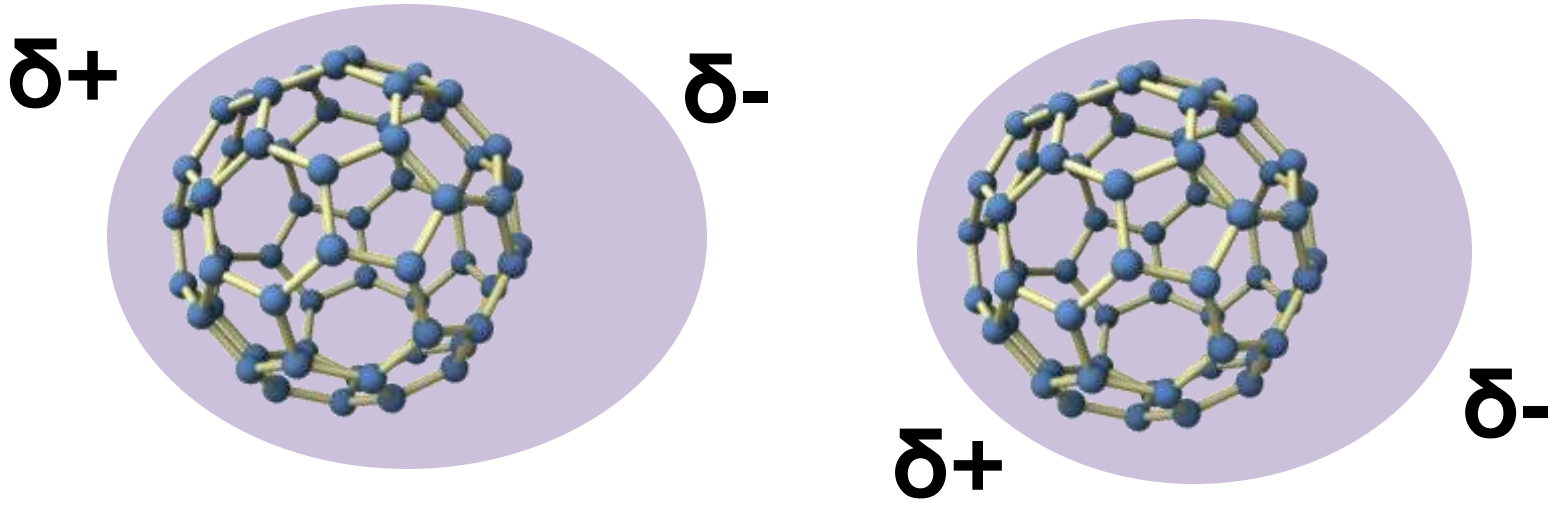

London Dispersion Forces

- Also called ‘van der Waals’ forces
- Weak intermolecular forces caused by instantaneous, temporary molecular dipoles
- Exist in all molecules

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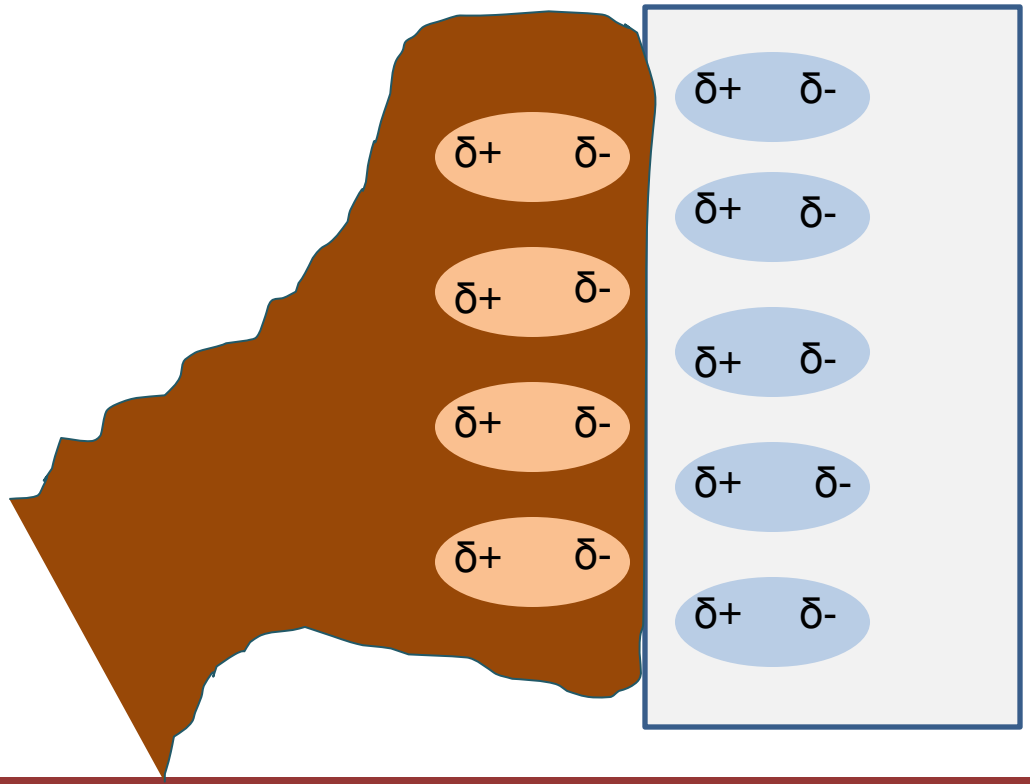
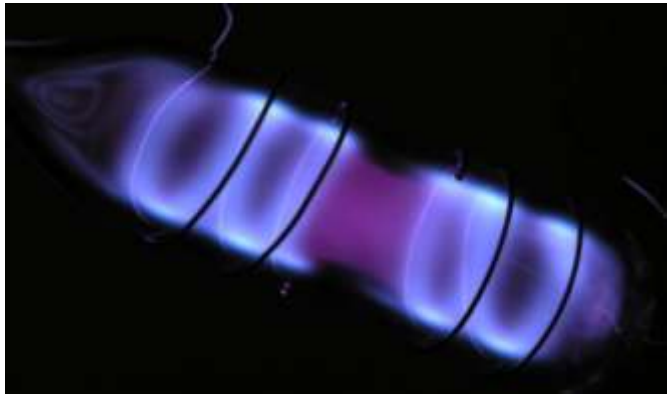


Mini-Quiz

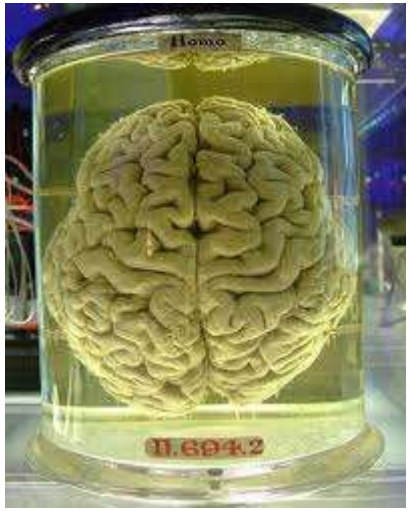
Which compounds below have London dispersion forces?

Xe



H_2O

CH_2O

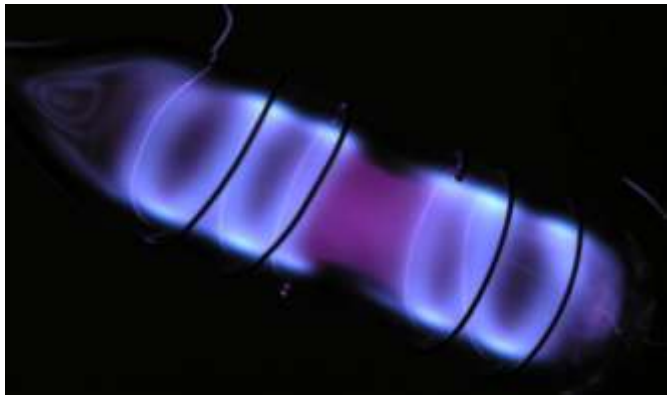


HF

Mini-Quiz

Which compound below has the greatest London dispersion forces?

Xe



Ne

Kr

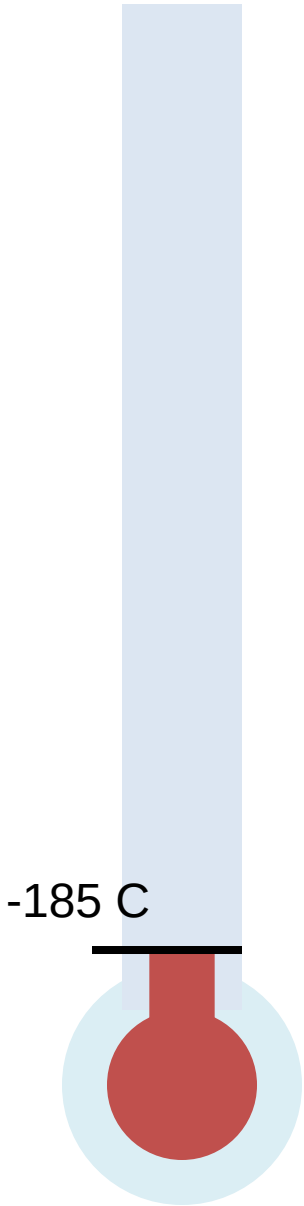
Outline

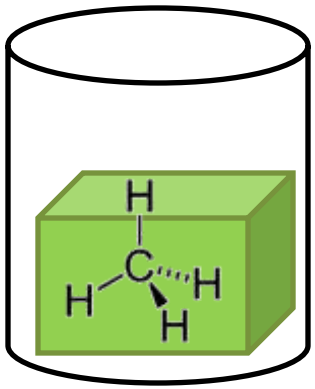
- Absolute Zero
- Intermolecular Forces
- Turning up the heat …

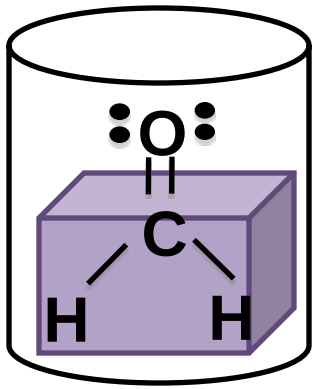
- 0 K
- Intermolecular Forces
  - Dipole-Dipole Forces
  - Hydrogen Bonding
  - London Dispersion (van der Waals) Forces
- Turning up the heat …

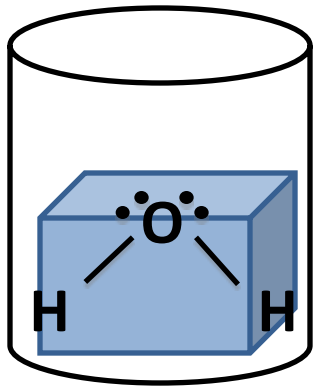
Turning up the heat …

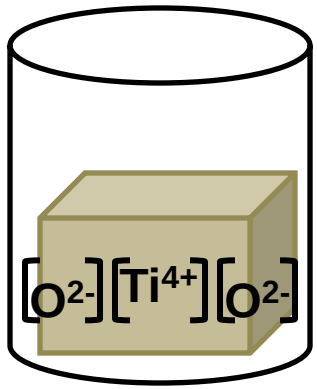
Methane **Formaldehyde** **Water** **Titanium Dioxide**





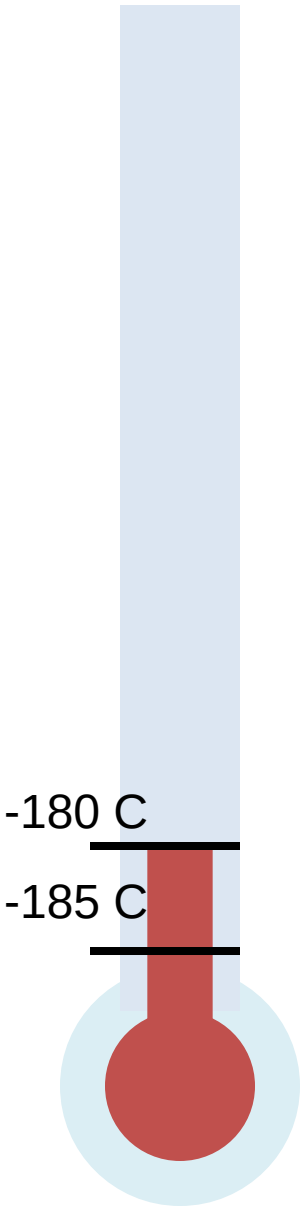


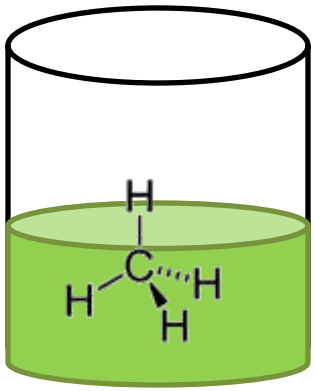


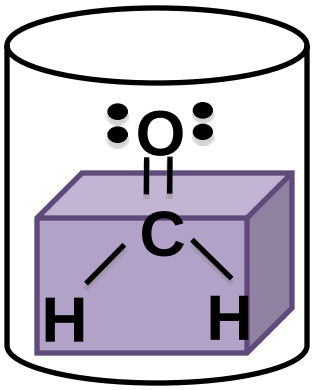


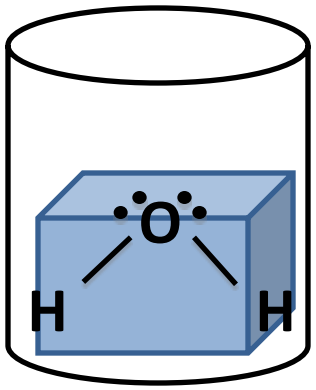
Turning up the heat …

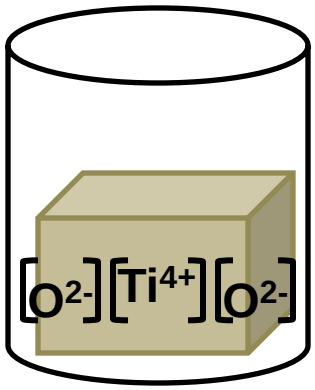
Methane	**Formaldehyde**	**Water**	**Titanium Dioxide**
London Dispersion	London Dispersion	London Dispersion	London Dispersion



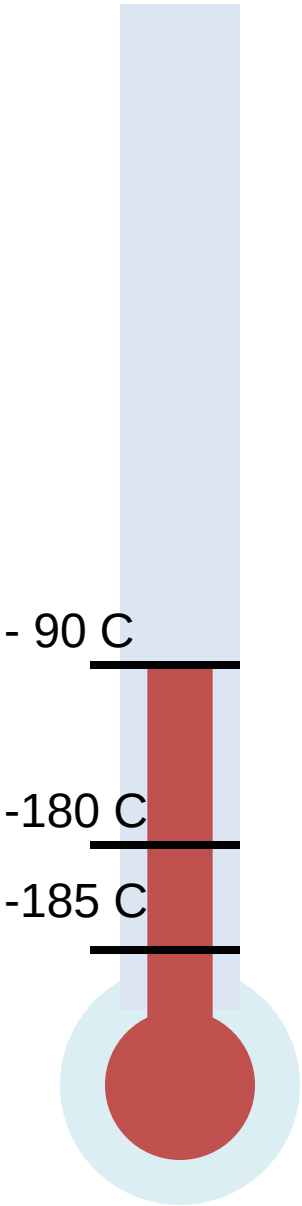




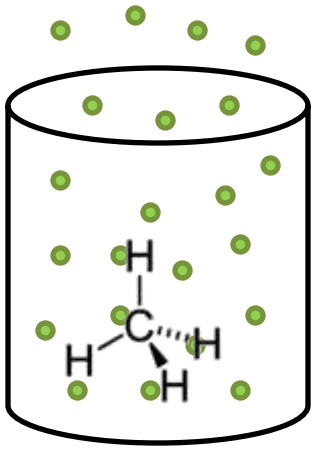


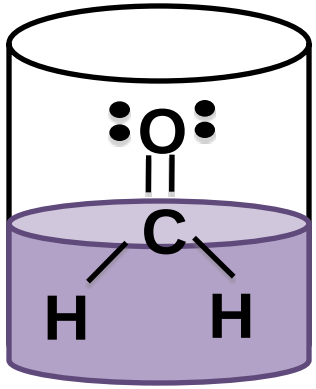


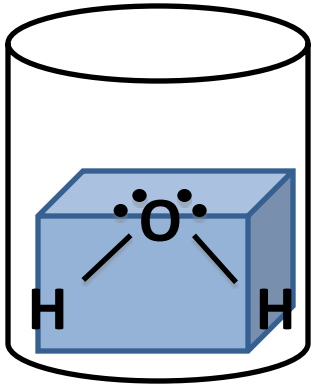
Turning up the heat …

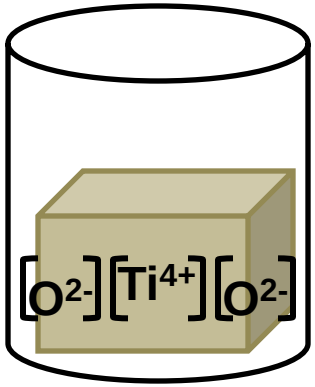


Methane	**Formaldehyde**	**Water**	**Titanium Dioxide**
London Dispersion	London Dispersion Dipole-Dipole	London Dispersion Dipole-Dipole	London Dispersion

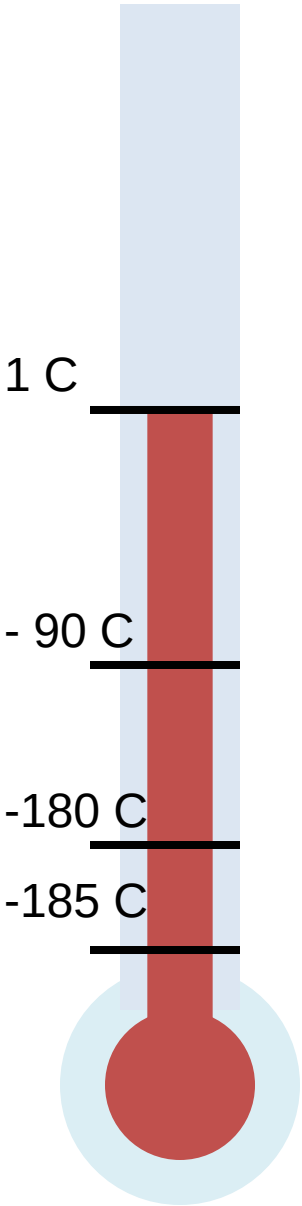




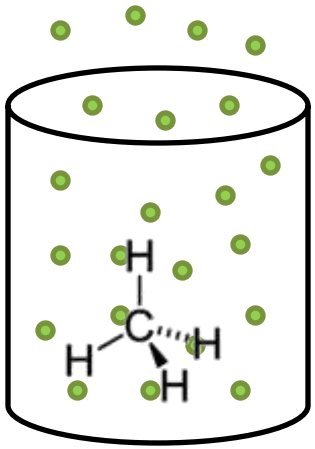


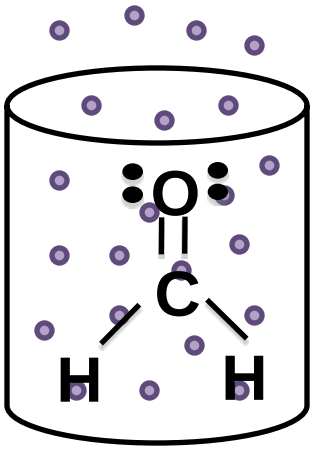


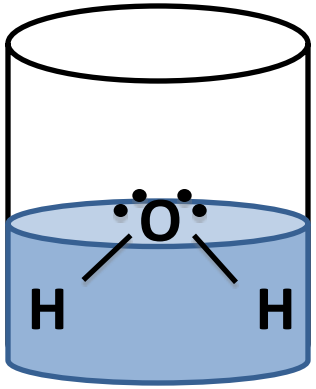
Turning up the heat …

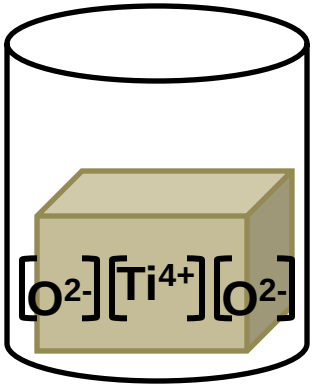


Methane	**Formaldehyde**	**Water**	**Titanium Dioxide**
London Dispersion	London Dispersion	London Dispersion	London Dispersion
	Dipole-Dipole	Dipole-Dipole	
		Hydrogen Bonding	









Turning up the heat …

2200 C

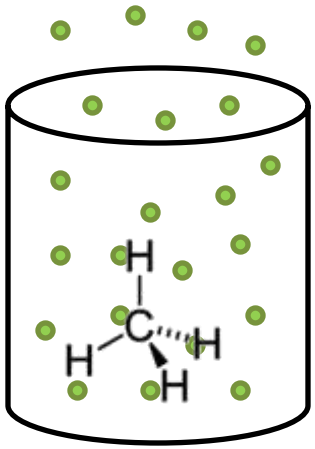
1 C

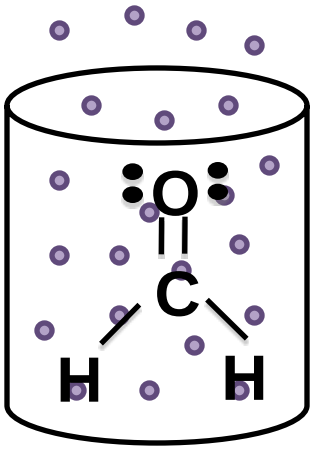
- 90 C

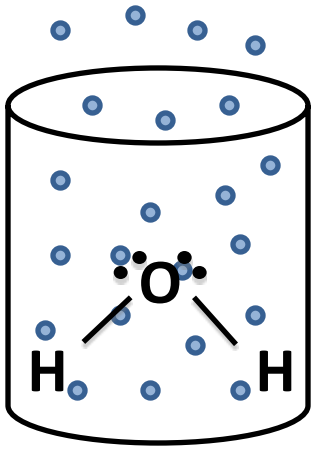
-180 C

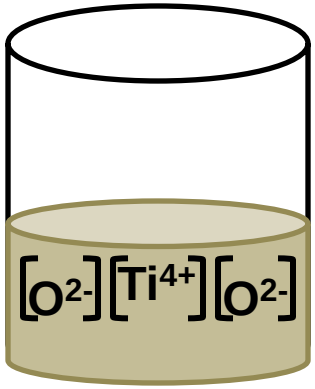
-185 C

Methane	**Formaldehyde**	**Water**	**Titanium Dioxide**
London Dispersion	London Dispersion	London Dispersion	London Dispersion
	Dipole-Dipole	Dipole-Dipole	
		Hydrogen Bonding	
			Ionic Bonding









Summary

- Intermolecular forces come from permanent and instantaneous dipoles between molecules
- Hydrogen Bonding > Dipole-Dipole > London Dispersion
- Stronger intermolecular forces = higher melting and boiling points

Homework

- TBD