Unit3Day5-Crawford

Wednesday, October 23, 2013
2:58 PM

Vanden Bout/LaBrake/Crawford

CH301

WHY IS EVERYTHING SO DIFFERENT?
Gas, Liquid or Solid?

UNIT 3 Day 5

Important Information

HW08 DUE Tue 9AM

Laude LM Lecture 16 & 17

What are we going to learn today?

Use VSEPR, VB & MO to get a better picture of POLAR and NONPOLAR MOLECULES

Recognize different molecules have different physical properties

Classify Intermolecular Forces (IMF)

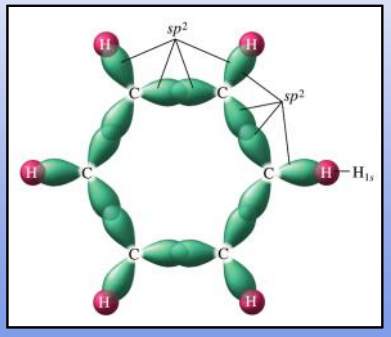
QUIZ: iClicker Question 1

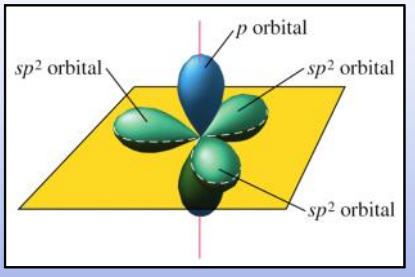
Chemists use a localized electron theory and a delocalized electron theory to help predict and explain bonding in molecules, these models are referred to respectively as:

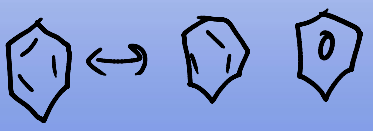
a) VSEPR, VB
b) VB, VSEPR
c) VB, MO
d) MO, VB
e) VSEPR, MO

COMBINE VB and MO THEORIES

VB for sigma bonds

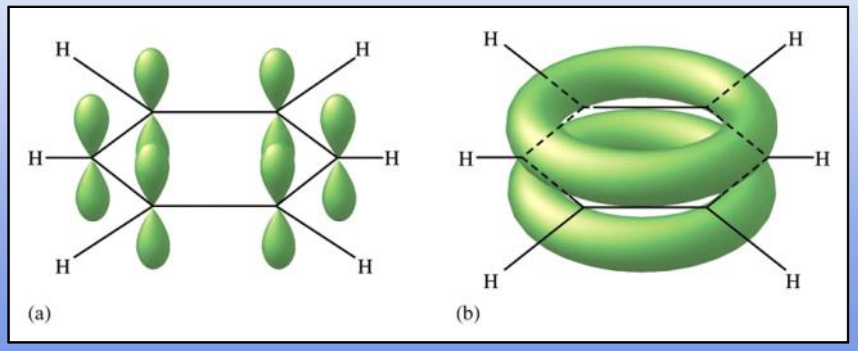






COMBINE VB and MO THEORIES

MO for the pi bond
Where are the electrons?
Delocalized around the molecule



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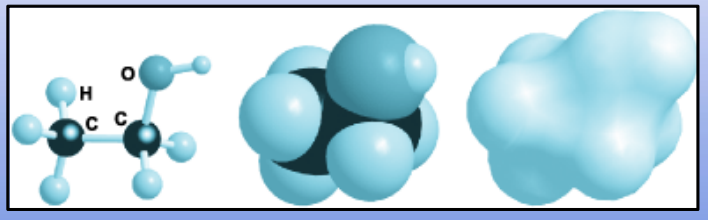
Visualize Ethanol

We use VSEPR and VB to get visual image

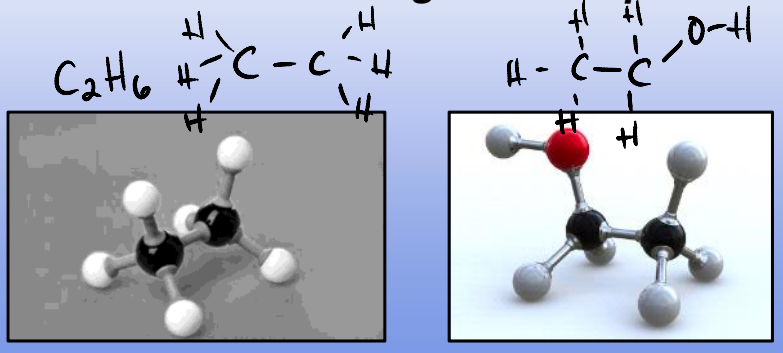
We predict polarity just from the ball and stick model



Chemical Composition & Shape

What are the Physical Properties?

Is the molecule a *gas* or a *liquid*?



Chemical Composition & Shape

What are the Physical Properties?

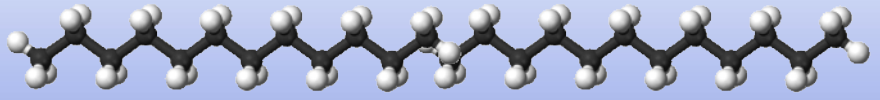
mass density

What is the *density* of a liquid?

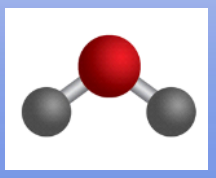
Chemical Composition & Shape

What are the Physical Properties?

What is the *density* of a liquid?



Oil



H_2O

Physical Properties

intra – within the molecule (covalent)

inter – between 2 or more molecules

What dominates the interaction in condensed phases?

What are these forces? How are they classified?

Define Intermolecular Forces (IMF).

NOTE: Remember Tape, Charged Rods and Liquids

Activity

Open Course Pack to Page 79
IMF Unit-Electrostatic Forces-Liquids

1. Draw the Lewis Structures
2. Identify any trends.

↳ Questions 1-4

Identify a Few Trends

Relationship between Chemical Formula and Boiling Point

1. MW↑ → ↑BP (sort of)
2. structure → BP (longer, ↑BP) sort of
3. high polarity → BP↑
4. ↑# of O-H bonds, BP↑
5.

Intermolecular Forces

Electrostatic

The dominate force in chemistry is **Coulombic**

$$E = \frac{q_1 q_2}{4\epsilon_o \pi r}$$

$E \propto \frac{\text{charge}}{\text{distance}}$

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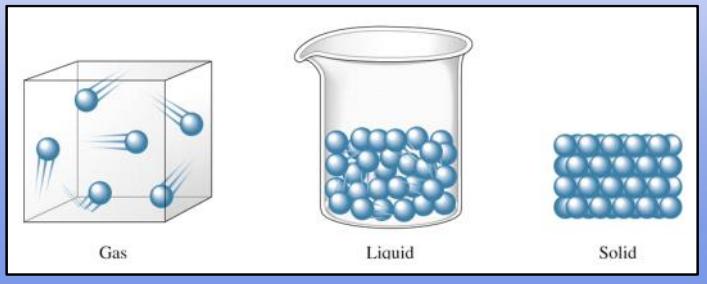
$$E = \frac{q_1 q_2}{4\epsilon_0 \pi r}$$

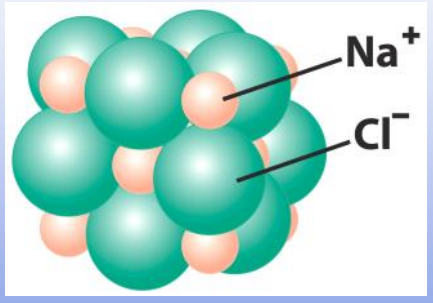
$E \propto \frac{\text{charge}}{\text{distance}}$

$E \propto \frac{1}{r}$



Intermolecular Forces

The dominate force in chemistry is **Coulombic**



The boiling point of NaCl is 1413 °C. Why is it *so* high?

Qualify the word “intermolecular”

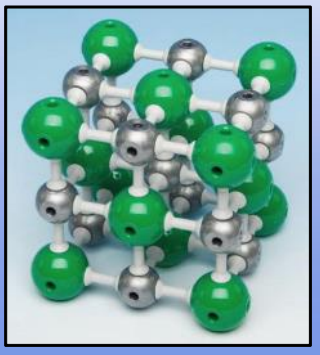
Intermolecular Forces

$E \propto \frac{1}{r}$

The molecule is in a condensed phase, but not ionic

A molecular condensed phase is a molecular liquid or a molecular solid

"PARTICLE IS A MOLECULE"



Intermolecular Forces: Dipole-Dipole

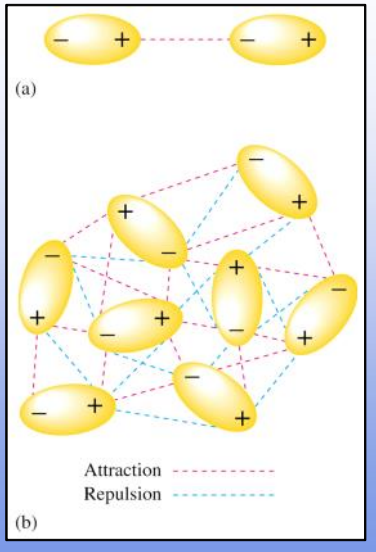
Attractive force between partial negative end of one molecule and partial positive end of another molecule.

Strength depends on distance and dipole moment.

$$E = \frac{1}{r^3}$$

$E \propto \frac{1}{r^3}$

* Molecule must be polar



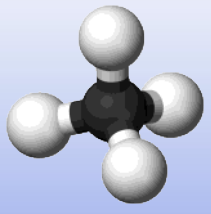
Poll: iClicker Question 2

ALL NONPOLAR COMPOUNDS ARE GASES:

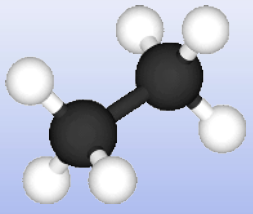
A) TRUE
B) FALSE

Look at the Data

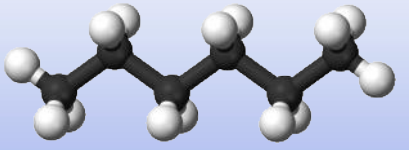
ALL NONPOLAR COMPOUNDS ARE **NOT** GASES



Methane
BP: -161 °C
Nonpolar
Gas



Ethane
BP: -88.7 °C
Nonpolar
Gas



Hexane
BP: 68.7 °C
Nonpolar
Liquid

Intermolecular Forces: Fact Check

How is it possible for Hexane and Carbon Tetrachloride to exist as liquids?

How is it possible for Octane to have a higher boiling point than Water?

How is it possible for Water and Ethanol to be attracted to a charged rod, whereas Hexane and Carbon Tetrachloride are not attracted to it?

There must be an ELECTROSTATIC ATTRACTION!

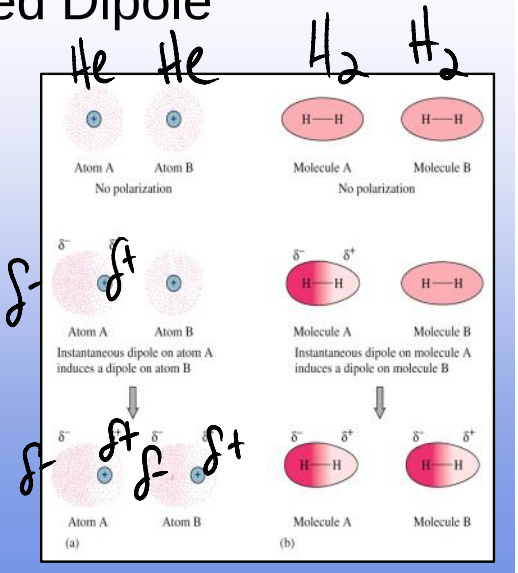
Intermolecular Forces: Induced Dipole-Induced Dipole

Everything has these forces

Induced Dipole-Induced Dipole interactions exist in **ALL** condensed substances

Caused by induced dipoles, which come and go in nonpolar molecules and atoms

$$E = \frac{1}{r^6}$$



$E \propto \frac{1}{r^6}$

Intermolecular Forces: Induced Dipole-Induced Dipole

This type of IMF goes by several different names:

Induced dipole – Induced dipole

Dispersion Forces

London Forces

This type of IMF goes by several different names:

Induced dipole – Induced dipole

Dispersion Forces

London Forces

Van der Waal's Forces

Poll: iClicker Question 3

Consider the following alkane data.

Alkane	MW [g mol^{-1}]	BP [°C]
Methane	16	-161
Ethane	30	-88.7
Propane	44	-42.1
Butane	58	-0.5
Pentane	72	36.1
Hexane	86	68.7

alkane

A molecule with a MW of 80 g mol^{-1} will be a _____ at room temperature.

A. Solid B. Liquid C. Gas

Poll: iClicker Question 4

Now consider an array of atoms and molecules

Alkane	MW [g mol^{-1}]	BP [°C]
Helium	4	-268.9
Krypton	83	-153.2
Propane	44	-42.1
CCl_4	154	77
Octane	114	126

The IMF strength is dependent on

E A, B, C

A. MW B. Shape C. Polarizability D. B&C

CCl_4	154	77
Octane	114	126

The IMF strength is dependent on

~~E A, B, C~~

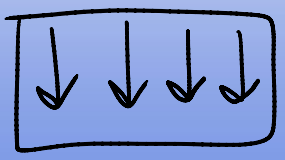
A. MW B. Shape C. Polarizability D. B&C

Polarizability

Induced Dipole-Induced Dipole forces exist in **ALL** condensed substances

Strength depends on **polarizability**

Element	Freezing Point (°C)
Helium*	−269.7
Neon	−248.6
Argon	−189.4
Krypton	−157.3
Xenon	−111.9



Shape

Why can't the charged glass rod induce a dipole?
Distance Dependence is **HUGE**

This is why shape is so important – how close can the individual atoms get to each other in space?

Common examples are oils vs. fats, and plastic wrap vs. milk jugs

FAVORITE ANALOGY - VELCRO

We can evaluate SIMILAR molecules

Ionic	MW [g mol^{-1}]	BP [°C]
LiCl	42	1382
NaCl	58	1413
KCl	74	1420

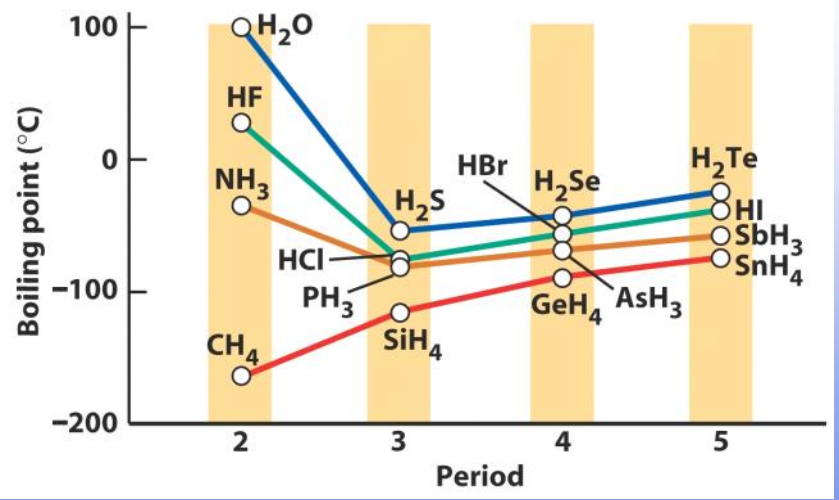
Alcohol	MW [g mol^{-1}]	BP [°C]
Methanol	32	65
Ethanol	46	78
Propanol	60	97

MWT, BPT

Alkane	MW [g mol^{-1}]	BP [°C]
Methane	16	-161
Ethane	30	-88.7
Propane	44	-42.1
Butane	58	-0.5
Pentane	72	36.1
Hexane	86	68.7

MWT BPT

Explore Real Data



Activity (IMF Unit-Electrostatic Forces-Liquids)
Course Pack Page 80

Poll: iClicker Question 5

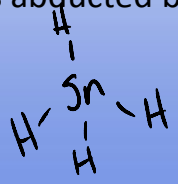
The BP of Sn hydride less than the BP of the Te hydride because: SnH_4 TeH_2

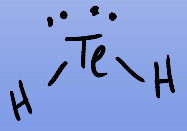
a) The Sn compound has a larger dipole

Poll: iClicker Question 5

The BP of Sn hydride less than the BP of the Te hydride because:

a) The Sn compound has a larger dipole
b) The Sn compound has a smaller dipole
c) The Sn compound is more polarizable
d) The Sn compound is less polarizable
e) Sn was abducted by aliens, obviously.





Poll: iClicker Question 6

The BP of S hydride less than the BP of the Te hydride because:

a) The S compound has a larger dipole
b) The S compound has a smaller dipole
c) The S compound is more polarizable
d) The S compound is less polarizable
e) The S compound has more friends

Poll: iClicker Question 7

BP does not seem to follow the trend for which period?

a) 1
b) 2
c) 3
d) 4
e) 5

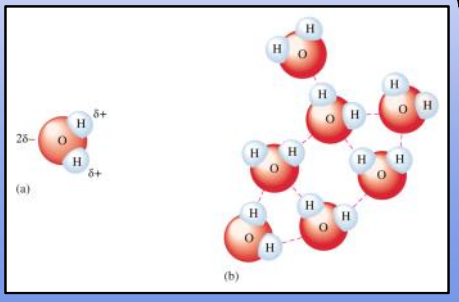
Intermolecular Forces: Dipole-Dipole

A special type of dipole-dipole forces is particularly strong, called **HYDROGEN BONDING**

Occurs in compounds with a H bound *directly* to F, N or O

H-F
H-N
H-O

Strength depends on distance and dipole moment, where a big dipole indicates a closer distance



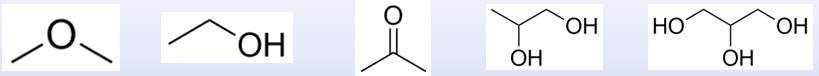
Poll: iClicker Question 8

The BP of O hydride is higher than the BP of the Te hydride because:

a) The O compound has a larger dipole
b) The O compound has a smaller dipole
c) The O compound is more polarizable
d) The O compound is less polarizable
e) The O compound has more hydrogen bonding

Poll: iClicker Question 9

Consider the following molecules.

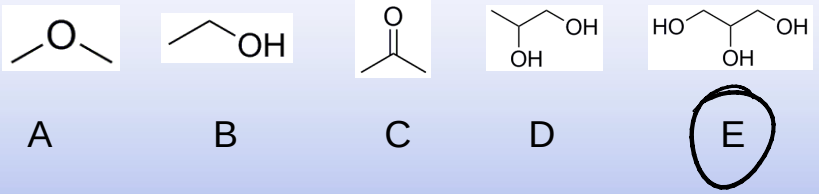


A B C D E

Which molecule has the lowest boiling point?

Poll: iClicker Question 10

Consider the following molecules.



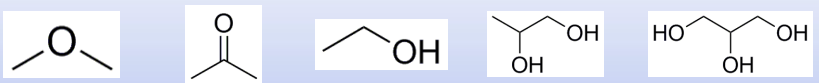
A B C D E

Which molecule has the highest boiling point?

smallest A < C < B < D < E

The **NUMBER** of Hydrogen Bonds is Very Important

Consider the following molecules.



BP	-24 °C	56 °C	78.5 °C	188.2 °C	554 °C
H-Bonds	**0**	**0**	**1**	**2**	**3**

Intermolecular Forces

There are also IMF between different "types" of compounds

Can you think of any examples of the following?

Ion – Dipole

Dipole – Induced dipole

Intermolecular Forces

Strength Varies with TYPE

Type of interaction	Typical energy ($kJ \cdot mol^{-1}$)	Interacting species
ion–ion	250	ions only
ion–dipole	15	ions and polar molecules
dipole–dipole	2	stationary polar molecules
	0.3	rotating polar molecules
dipole–induced dipole	2	at least one molecule must be polar
London (dispersion)†	2	all types of molecules
hydrogen bonding	20	molecules containing N, O, F; the link is a shared H atom

What have we learned today?

PHYSICAL PROPERTIES DEPEND ON COMPOSITION & SHAPE OF COMPOUND

CLASSIFY INTERMOLECULAR FORCES
ION-ION vs. DIPOLE-DIPOLE vs. INDUCED DIPOLE – INDUCED DIPOLE

PREDICT WHAT TYPE OF IMFs EXIST FOR A PARTICULAR COMPOUND

Learning Outcomes

Define the three major types of intermolecular forces (IMF) discussed in class: dipole-dipole, H-bonding, and dispersion (London, van der Waals, induced dipole-induced dipole, instantaneous dipole-instantaneous dipole)

Explain how molecular size and shape affect the magnitude of the dispersion forces