10-29-13

Which has lower boiling point?
-cis- unsaturated fatty acid
* double bonds don't intake because of pi bond

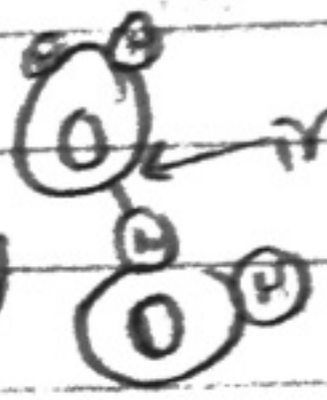
-trans- unsaturated fatty acid
↑ double bond
↑ inflexible, straight molecules can stack up well

trans - straight - solid - man-made
cis - kanked - liquid - natural

Dipole-dipole $E = \frac{1}{r^3}$
-important in polar molecules & has distance dependence

Hydrogen bonding
H-O →
H-F → > more important
H-N →

If oxygen is pulling on hydrogen's one electron, molecules can get close together
- short bonds are strong bonds



← intermolecular force - hydrogen bond.

Induced Dipole - Induced Dipole $E = \frac{1}{r^6}$
on molecular scale this is important force

Stronger IMF → higher boiling point

increasing polarizability → stronger dispersion
(growing distance between molecules)

electronegativity difference goes down → boiling point goes down

- hydrogen bonding increases boiling point

Ion-Dipole ← Na^+ in H_2O

like chemical bond

- ion forces in aqueous solution are weak

Type of interaction	Typical energy $KJ \cdot mol^{-1}$	Interacting Species
ion-ion	→ 250	Ions only

$PV = nRT$ Ideal Gas Law

$P(V - nb) = nRT$ Hard sphere model

$\left(P - \frac{an^2}{V^2}\right)(V - nb) = nRT$ van der Waal's equation

↑ attraction

Repulsion

↑ predicts existence of liquids (approximately)

H_2O ← polar
- Dipole-Dipole
- H-bonding

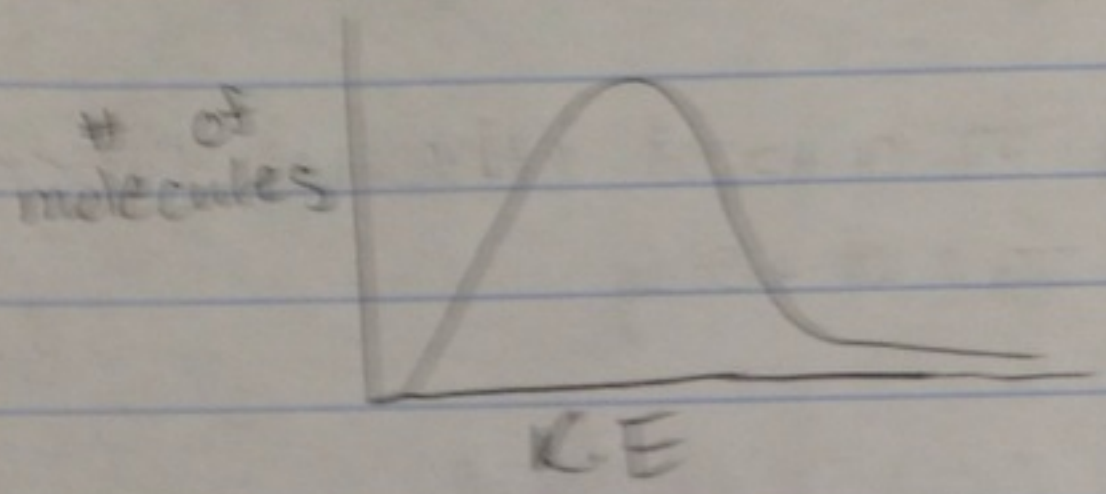
↑ not very ideal gas. Particularly as pressure is increased

- big molecules will probably not react ideally
- gases have weak forces.

Properties of Liquids

- the more molecules stick together, the more temp is needed to break apart

-Boltzmann distribution



-certain amount of E needed to overcome molecular forces

KE > E

-if there is no lid on container, molecules will fly off

-w/ a lid, molecules will be forced to stay in one place & will even go back into liquid

In a closed container, why does the pressure of the vapor not continue to increase?

- Because at a certain point, the amount of vapor coming out is the same as same as what is going in

- weak IMF = high VP

Which would have higher vapor pressure?

a) CH_3CH_2OH (b) CH_3OCH_3 c) They would be the
no hydrogen bonds

→ viscosity should be high for hot temps.

Boiling is not evaporation
Boils when VP ≥ atmospheric
High VP → low BP
low VP → high BP

- put pennies in cup of water. Observation
  - water higher than edge

- put pennies in cup of ethanol. Observation
  - ethanol sort of rising

- put pennies in cup of acetone
  - acetone spills out

Which has higher energy?
- surface molecule
  ↑
  don't interact w/ many other molecules,
  so fewer IMFs, higher energy
  ↑
  will always try to minimize the amount of surface
  ↑
  will adopt spherical shape (water droplets)

- water has high surface tension
  - "breaking surface" requires more energy
- surface tension & IMFs are directly related
- molecules behave differently at surface than in bulk

Viscosity: resistance to flow
- Strong IMF → high viscosity
- long molecules can flow & tangled cannot

Liquid Properties

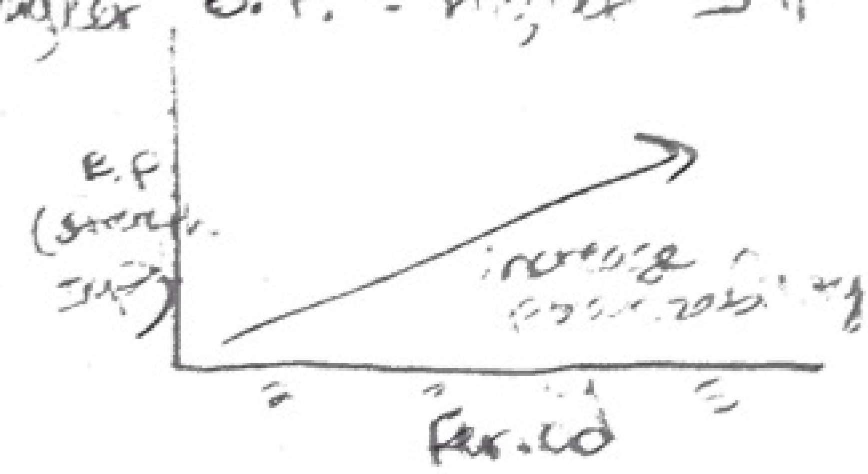
Important
- LM 24 > Due Thurs.
- LM 25

Learning
- properties in terms of IMF

Clicker Question.
- All of the following are terms used to describe the type of intermolecular forces that exist in ALL condensed phases of matter, Except
  - ion-ion
- Which of the following has a lower boiling pt.
  - cis-unsaturated fatty acids

- molecules have to pack tightly for there to be a higher intermolecular forces
- cis-unsaturated - natural, liquid
- trans-unsaturated - man made, really bad for you

- shorter chains = stronger chains
- higher B.P. = higher IMF



The boiling pt. of NH_3 is higher than SbH_3 because the N compound has more hydrogen bonding
- H (N,O, [illegible]) - [illegible] of the strongest intermolecular force

Intermolecular Forces:
- Ion-dipole
  - [illegible] force [illegible] aqueous solution [illegible]

- Dipole - Induced Dipole
  - dissolve O_2 in H_2O

Intermolecular forces

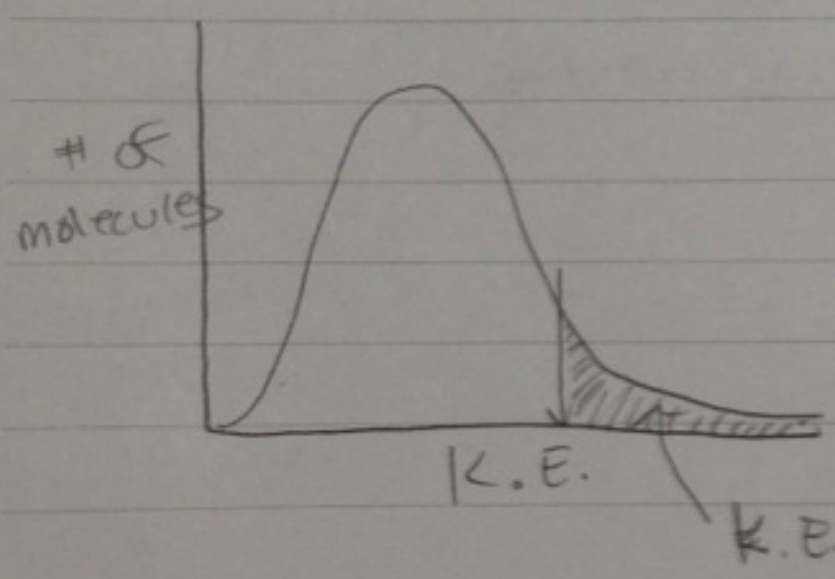
- $PV = nRT$ Ideal gas law (NO IMF)
- $P(V - nb) = nRT$ talk about repulsion
- $(P - \frac{an^2}{V^2})(V - nb) = nRT$
  - attractions

Clicker Question

- Which compound do you think would deviate most from the ideal gas law?
  - H_2O because it is polar, dipole-dipole, + hydrogen

Properties of Liquids (Room temp)

- What is vapor pressure? NOT BOILING POINT



certain amnt. of E to overcome IMF

- In a closed container, why does the pressure of the vapor not continue to increase?
  - Because at a certain point, the amt of vapor coming out is the same amount going back in

* • weak IMF = high vapor pressure
  - If vapor pressure is higher than the atmospheric pressure, then the
- Which do you think has the higher vapor pressure?
  - CH_3OCH_3 (no hydrogen bonding)

- something boils when vapor pressure ≥ atmospheric pressure
  - high V.P. (at R.T.) → low B.P.

Penny Demonstration

- water
  - water bulges at the top
- ethanol
  - in between
- aceton
  - spill, will never bulge

- which has a higher energy?
  - surface molecule
    - don't interact with as many molecules
    - Few IMF = higher in energy

Surface Tension

- "Breaking surface" - requires more area
- surface tension and IMF's are directly related
- higher IMF = higher surface tension

Viscosity

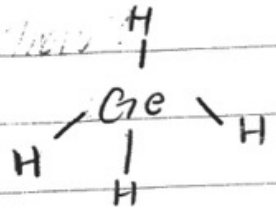
- molecular weight and the shape
- resistance to flow
- strong IMF = high viscosity
- bigger / more branched is harder to flow through
- control viscosity along with shape

Intermolecular forces

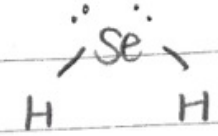
intramolecular
- strongest
- w/ in the molecule Ionic/covalent

intermolecular
- ion-ion $E \propto \frac{1}{r}$
- dipole-dipole $> \frac{1}{r^3}$
- H-bond
- London $\frac{1}{r^6}$

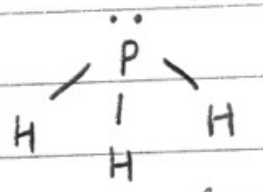
ionic
polar H-F, H-O, H-N
↑ covalent
All!

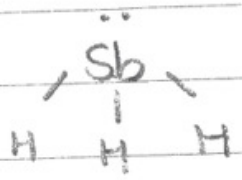


non polar



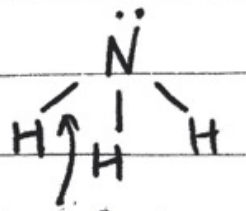
polar

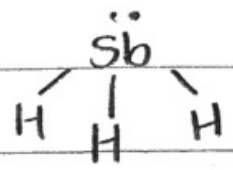




less polarizability

- Going down group adding more polarizability b/c more she
- More e⁻ = more polarizability
- one side is more negative than other @ some pt

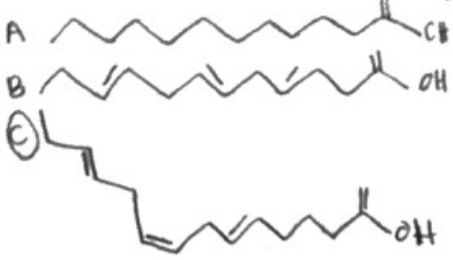




October 29

Recap Intermolecular forces

- Ion forces ARENT in all molecules
- which has lower boiling point?



(highest BP easily stacked)

← less easily stacked

Intermolecular

The molecule is in a condensed phase, but not ionic

between molecule

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

H - bond

Dipole-Dipole $E \propto \frac{1}{r^2}$

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

Intramolecular

strongest w/in molec. Ionic/Covalent

H-F
↑ covalent bond that brings hydrogen bond btwn. molecule

Ion-dipole ex. salt in water ions & polar molecules

Dipole - Induced dipole ex: oxygen in water

what about condensed phases?

$PV = nRT$ → no IMF

Hard sphere, van der Waals

What deviates most at Ideal Gas Law?

H_2O! b.c. highest IMF (hydrogen bond)

PROPERTIES OF LIQUIDS

Vapor pressure - the dynamic equilibrium where the rate of evaporation of the liquid = rate of condensation

vapor pressure ↑ 760 torr Causes explosion

strong IMF, high BP, so can't get to high VPressure

↓BP ↑VP weak IMF

↑ surface tension
↑ IMF

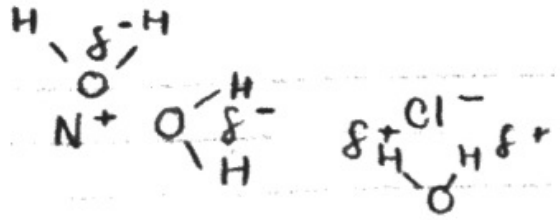
Surface molecule ↑ energy bc less stable

* viscosity - resistance to flow
  - syrup
  - honey
  - molasses

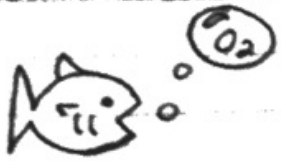
Bulky = high viscosity
↑ temp = low viscosity

ion-dipole

saltwater



dipole - induced dipole



dissolved O_2

Intermolecular Forces

PV = nRT Ideal Gas Law (no IMF)

Hard Sphere / Vaander Waals

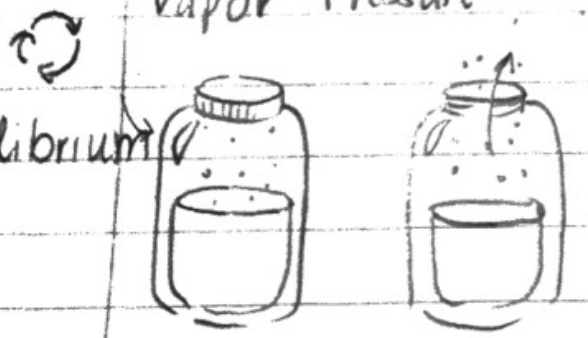
* size matters!

H_2O would most deviate from ideal gas law

H_2O = 18g per mol but 100° = boiling

highest / strongest intermol force (H-bonds)

Vapor Pressure



if > atm will explode

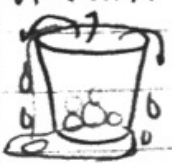
more H-bonding causes higher the boil pt

stronger intermol force will stay together as a liquid phase

lower the vapor pressure

↑BP ↓VP Strong IMFs
↓BP ↑VP Weak IMFs

Acetone
cold enough
VP < atm



Ethanol
in between

H_2O
Surface tension

strong IMFs H-bonds grabbing on

Surface molecule has higher E because whatever is held more stable = lower E
Bulk molecule in H_2O surrounded so it's stable.

Hydrogen-Bonding
ST has to do w/ strong intermol. forces
Viscosity - resistant to flow.
syrup, molasses, honey, H_2O
very high

Higher MW = higher Viscosity

OH (isomers) bigger & bulkier = resistant to flo
OH

biggest molecule @ colder temperature