Which has a higher Enthalpy?

A. liquid water

B. gaseous water 

C. they are exactly the same

D. it depends on the temperature

What in the world is Enthalpy?

If somehow you have forgotten last semester, then you need to know that Enthalpy is essentially Energy

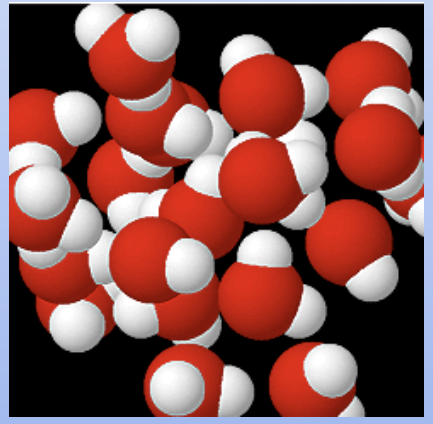
Technically, the change in enthalpy ΔH for a process at constant pressure is equal to the heat

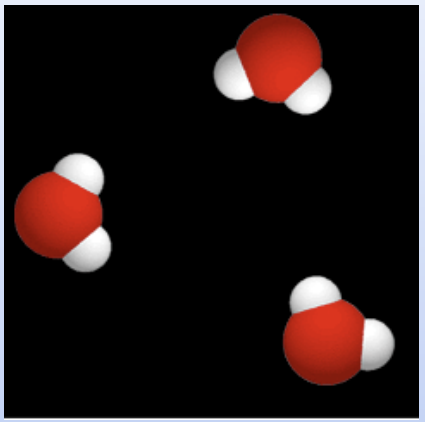
Conceptually it is easiest to think about it as the Energy
Low Enthalpy = Low Energy (stable, bottom of the hill)
High Enthalpy = High Energy (top of the hill)

Why do different phases have different Enthalpies? Intermolecular Forces (IMF)

Liquid

Molecules Close Together
Intermolecular Forces are Attractive
Lower enthalpy (energy) compared to molecules that are separated

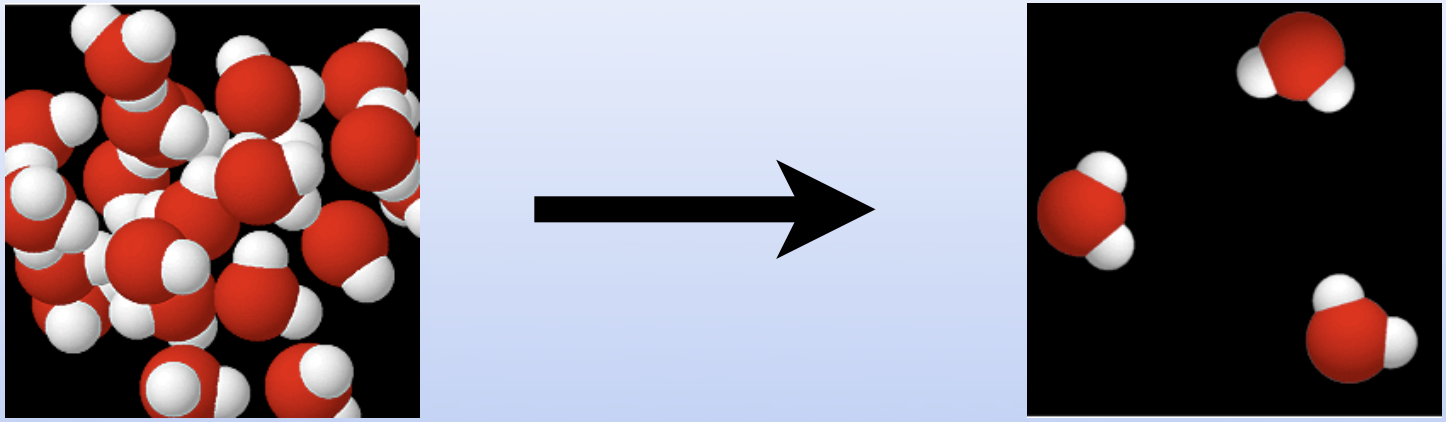




Gas
Molecules Very far apart
essentially no interactions
no IMF = higher energy

Enthalpy

Comparing the two



Attractive IMF
Lower H

No IMF
Higher H

We need to put in energy to overcome
the molecules attractions for each other

$$\Delta H_{vaporization} = H_{gas} - H_{liquid} > 0$$

remember: positive change in energy is energy into the system

Which has a higher Entropy?

A. liquid water

B. gaseous water 

C. they are exactly the same

D. it depends on the temperature

A quick review of Entropy

The entropy technically depends on the number of equivalent microstates of a system.

How to deal with this qualitatively today?

Entropy increases with increasing volume

Entropy increases with increasing temperature

Entropy increases with increasing the number of molecules

Entropy increases with going from a solid to a liquid to a gas

The Universe tends towards higher entropy

Which has a lower Gibb's Free Energy?

A. liquid water

B. gaseous water

C. they are exactly the same

D. it depends on the temperature 

Stability is governed by Free Energy
It is the balance between lower Enthalpy (energy) & higher Entropy

State with the lowest free energy (G) is most stable

$$G = H - TS$$

therefore at low temperature
the state with lowest H will be the most stable
(dominated by energy)

at high temperature
the state with the largest S will be the most stable
(dominated by entropy)

What if there were no IMF?

If molecules were not attracted to each other
they would all wander away from each other
and end up spread out all over the universe

This is entropy

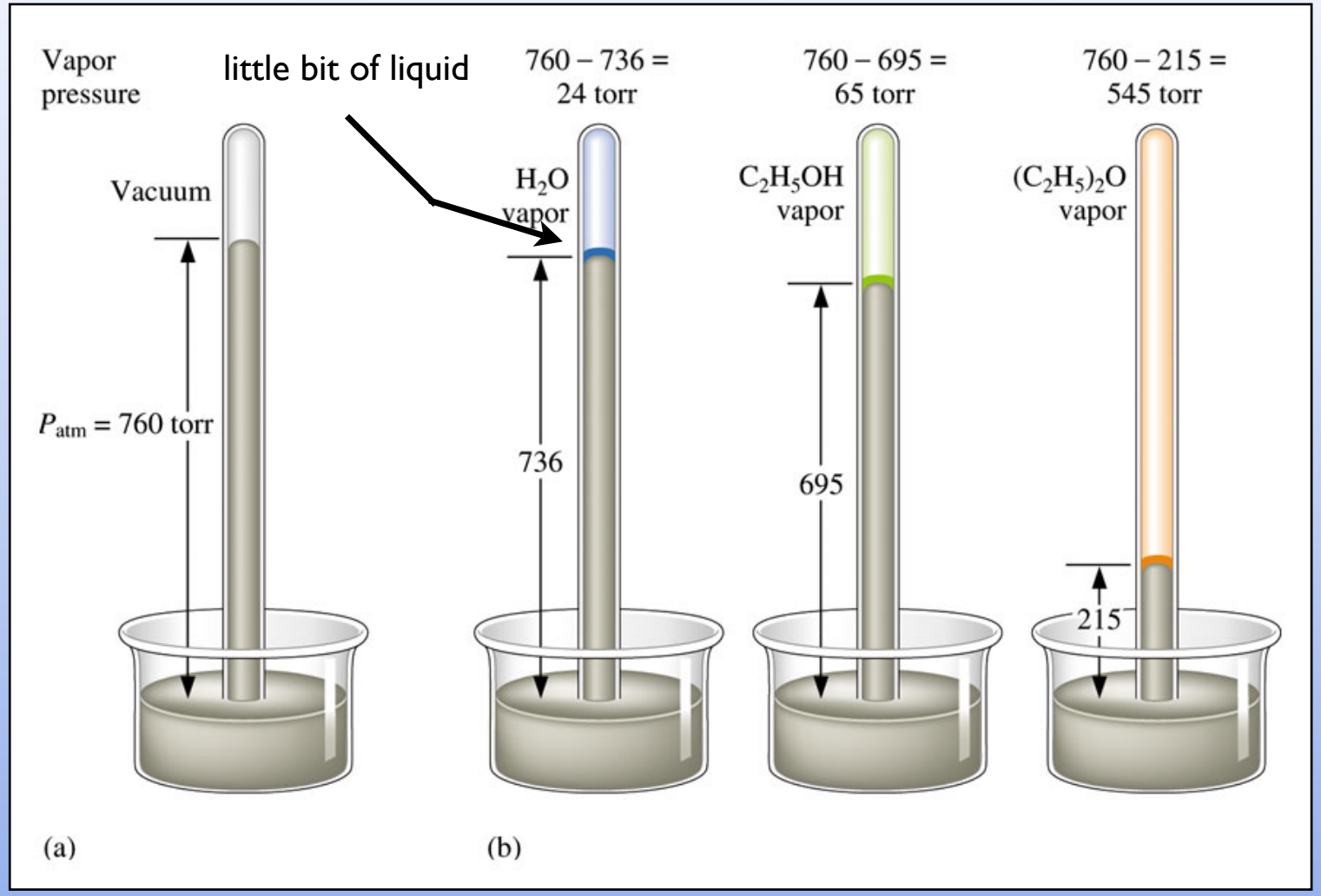
IMF hold them back

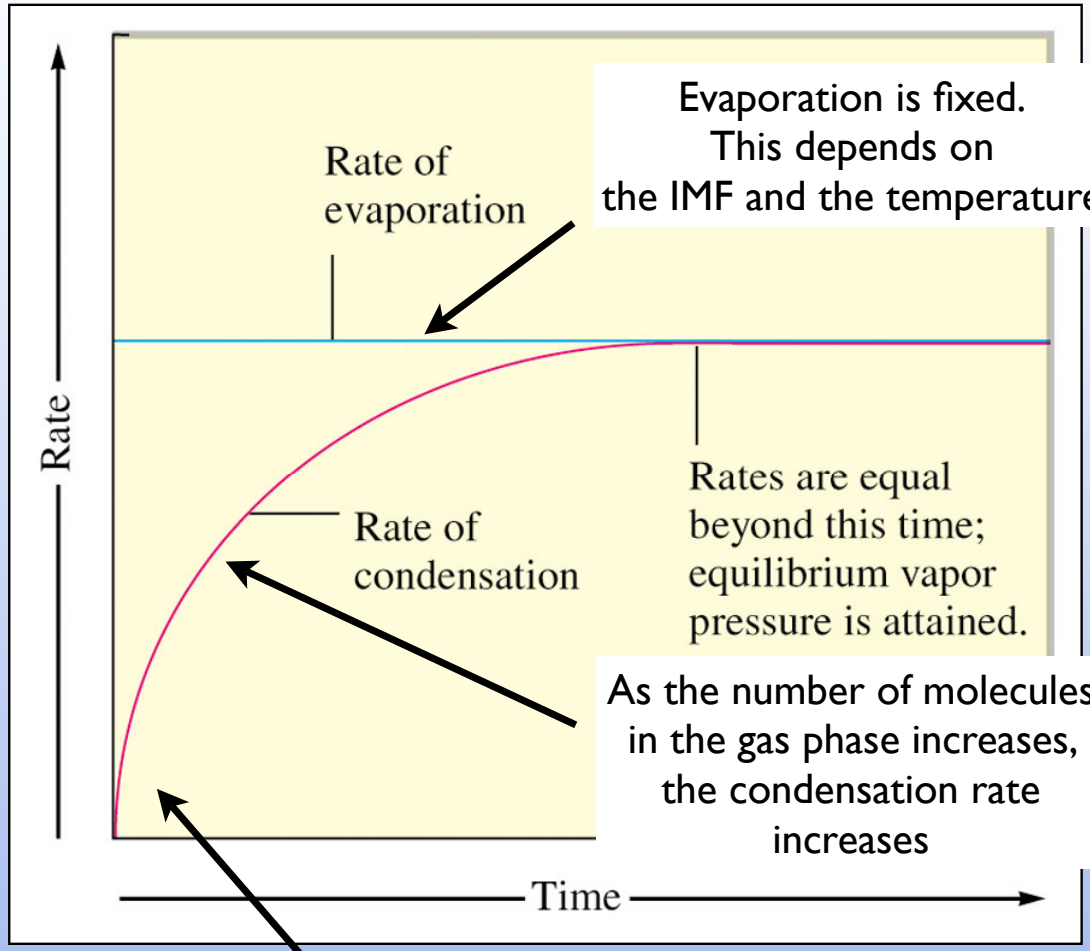
there are always some molecules
that have enough energy to escape

at higher temperatures more
molecules that can overcome the IMF

This is evaporation

We can measure how many molecules "escape" This is the vapor pressure





Evaporation is fixed.
This depends on
the IMF and the temperature

As the number of molecules in the gas phase increases, the condensation rate increases

Condensation starts out slow
Since there are initially
no molecules in the gas phase

Vapor Pressures at 25°C

Water	24 Torr
Diethyl Ether	545 Torr
Ammonia	7600 Torr
Methanol	127 Torr
Ethanol	65 Torr
Propanol	44 Torr
Butanol	7 Torr

Why does butanol (C_4H_9OH) have a lower vapor pressure than methanol (CH_3OH) at 25°C?

A. butanol has a higher entropy

B. butanol has stronger inter molecular forces

C. butanol has a lower molecular weight

D. butanol has a higher density

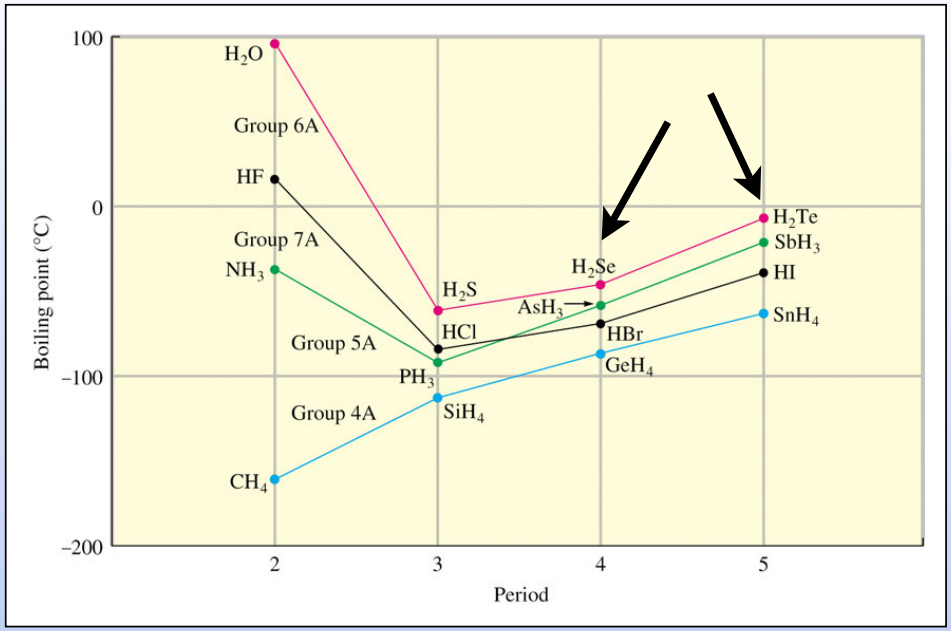
Intermolecular forces lead to the enthalpy difference between the liquid and the vapor

The larger the IMF the larger the ΔH_{vap}

The larger the ΔH_{vap} the smaller the vapor pressure

The the smaller the vapor pressure the higher the boiling point

Compound	VP (Torr)	ΔH_{vap} (kJ mol^{-1})
Water	24	40.65
Diethyl Ether	545	27.4
Ammonia	7600	23.35
Methanol	127	37.8
Ethanol	65	38.5
Propanol	44	47.5
Butanol	7	51.6



Why is the boiling point of H_2Te higher than H_2Se?

A. H_2Te has a larger dipole

B. H_2Se has more dispersion forces

C. H_2Te has more dispersion forces ←

D. Both A & C

at the same temperature H_2Te will have a lower vapor pressure, thus it will need to get to a higher temperature before it is equal to one atmosphere (boiling)

