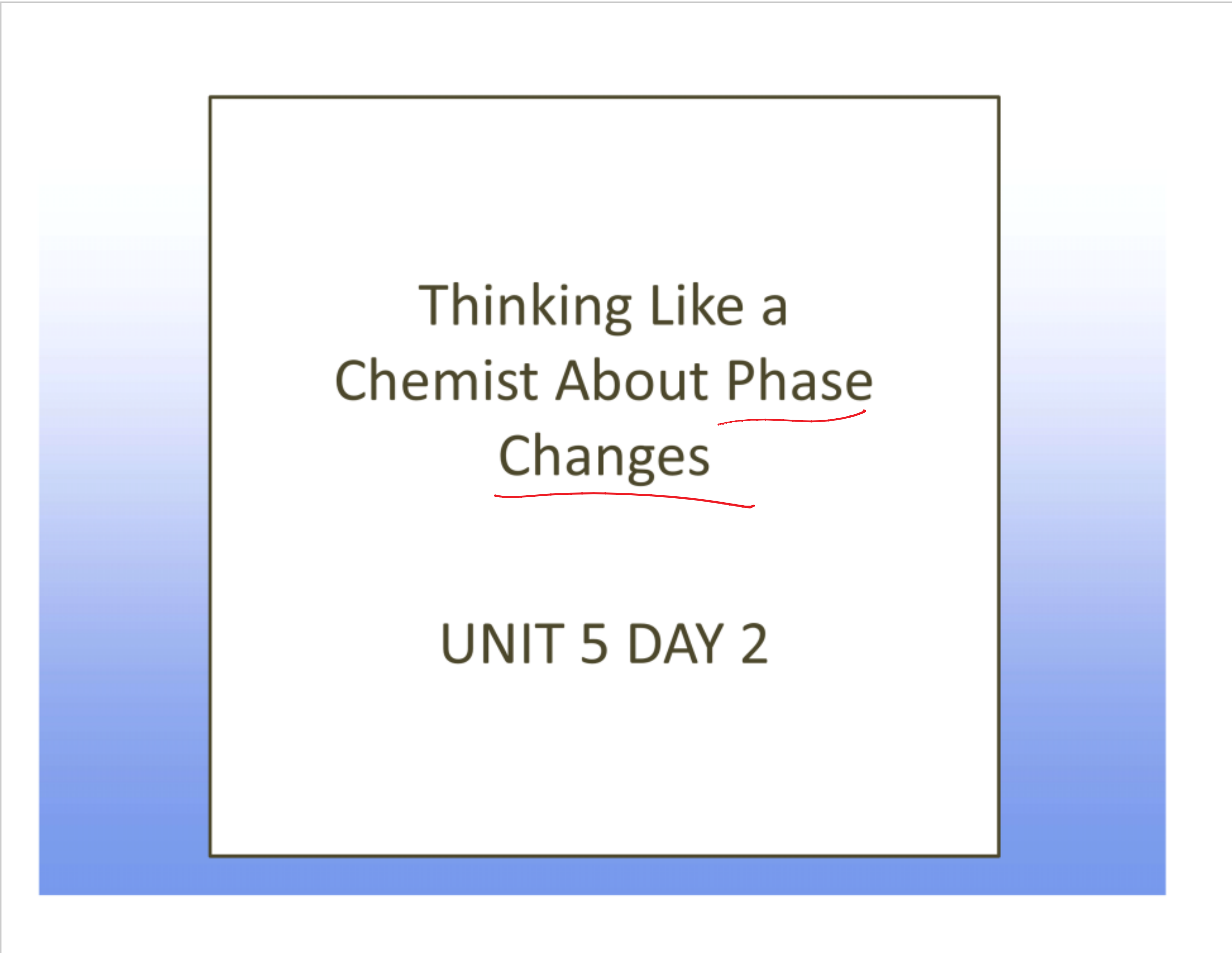
Unit5-Day2-VDB

Thursday, January 16, 2014
8:33 AM



What are we going to learn today?

Do your homework (HW and LM)
Become familiar with the course website

Quick pre-assessment – do your best.

Thinking Like a Chemist in the context of Phase Changes

- Vapor Pressure
- Boiling/Condensation
- Phase Diagram

ANNOUNCEMENTS

<u>Sapling</u>

HW1	DUE Tue 9AM

<u>Canvas</u>

LM04 – Phase Diagrams	DUE Tue 9AM
LM05 – Vapor Pressure	DUE Tue 9AM

Quiz Question 1

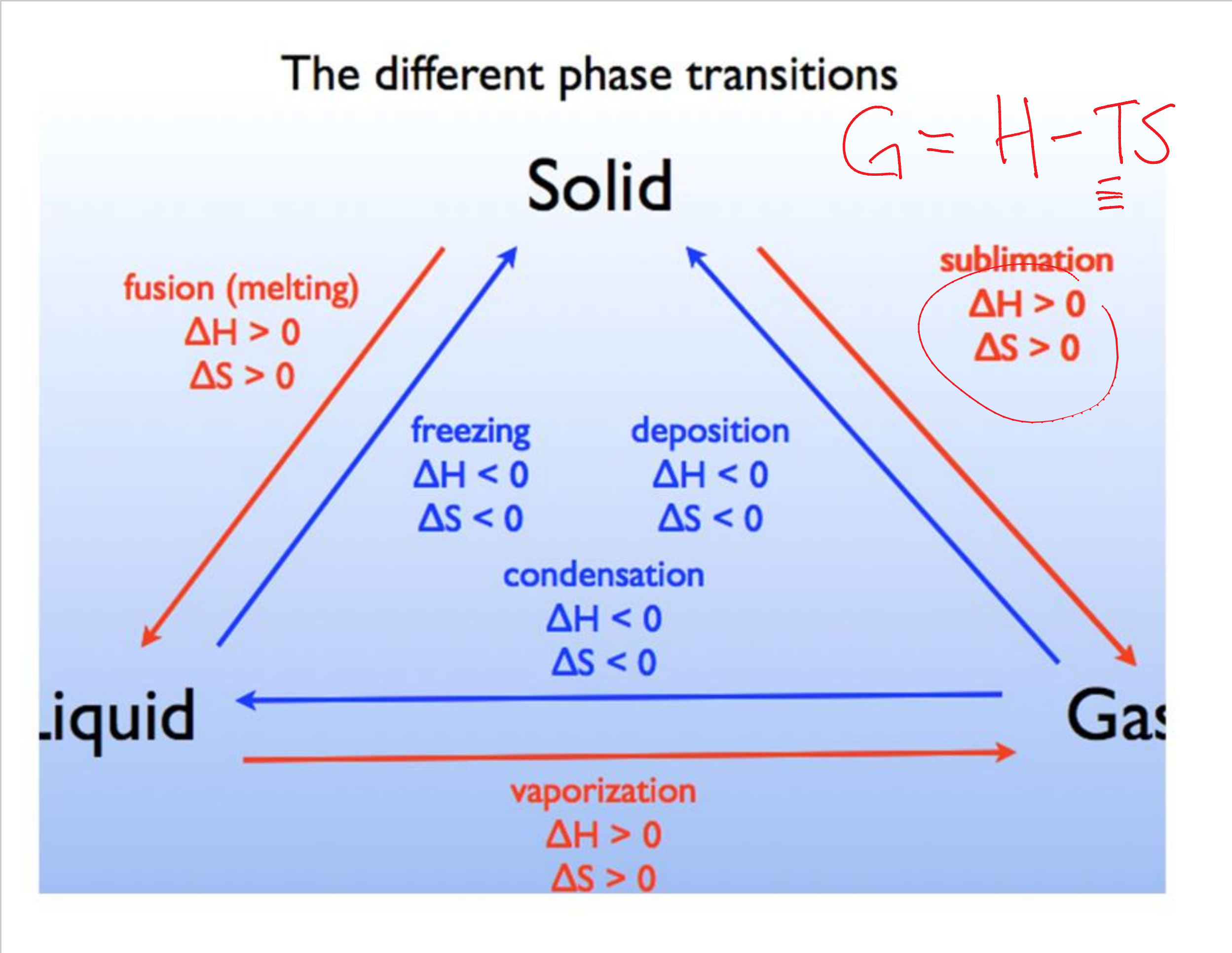
The sign for ΔH_{vap} is:

a) always "-"
b) always "+"
c) could be "+" or "-" depending on T
d) could be "+" or "-" depending on IMFs

Quiz Question 2

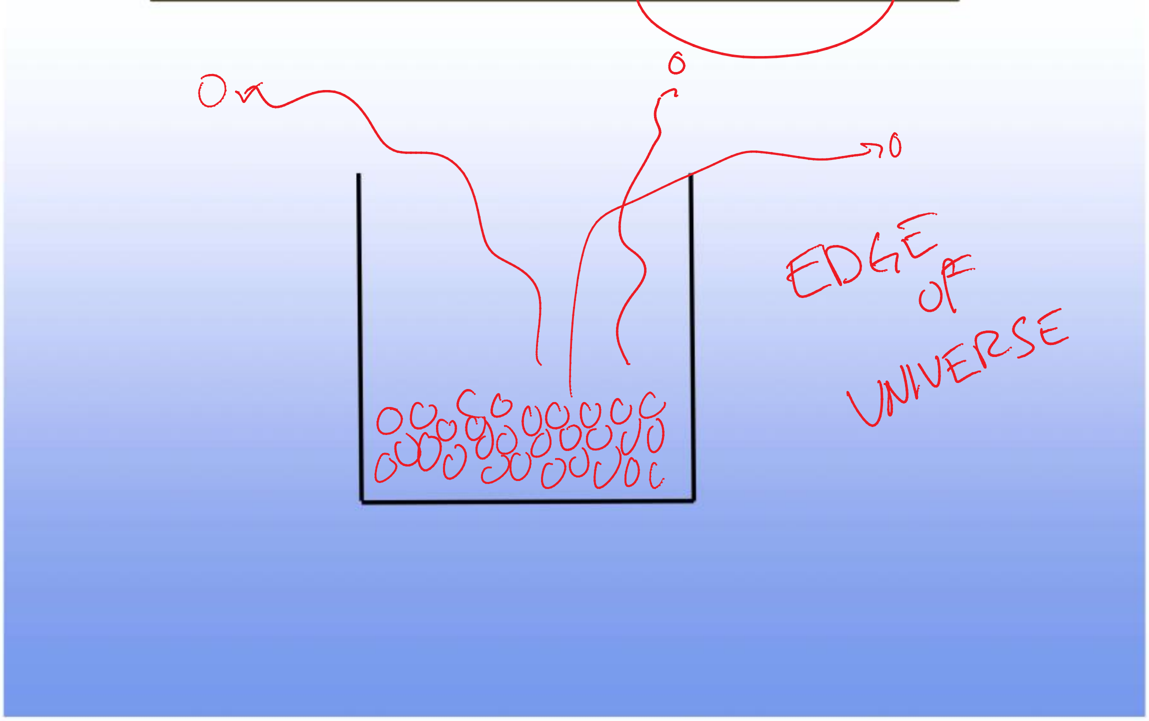
The sign for ΔS_{fus} is:

a) always "-"
b) always "+"
c) could be "+" or "-" depending on T
d) could be "+" or "-" depending on IMFs

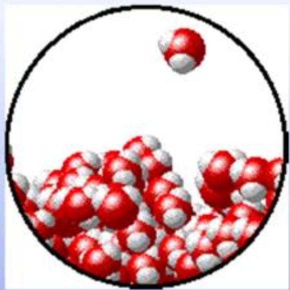


The different phase transitions
G = H - TS
Solid
Liquid
Gas
fusion (melting)
ΔH > 0
ΔS > 0
sublimation
ΔH > 0
ΔS > 0
freezing
ΔH < 0
ΔS < 0
deposition
ΔH < 0
ΔS < 0
condensation
ΔH < 0
ΔS < 0
vaporization
ΔH > 0
ΔS > 0

What if there were no IMF?



What if there were no IMF?



If no attraction molecules would wander away and spread out all over the universe.

This is entropy.

IMF hold them back

But… what about evaporation?

To think about evaporation we need to think about the temperature and kinetic energy of molecules.

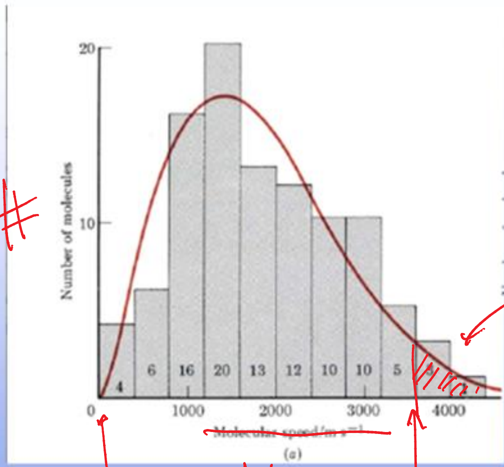
For a sample at some fixed temperature,

A. All molecules in the sample have the exact same kinetic energy.

A. There is a distribution of kinetic energies for molecules in the sample.

B.

Boltzmann distribution explains EVAPORATION!



# of molecules @ each K.E.

TAIL

all action is HIGH KE

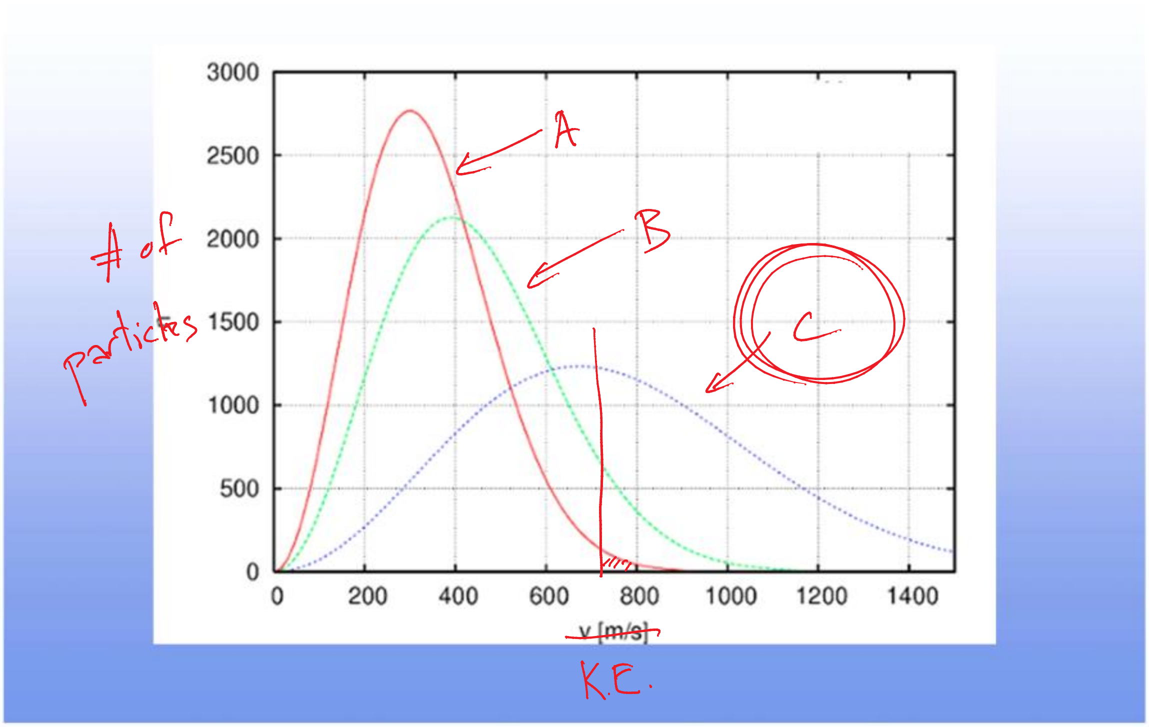
K.E.

min E need overcome IMF

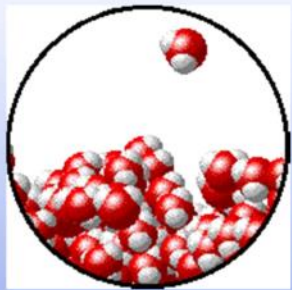
What happens to the distribution when you increase T?

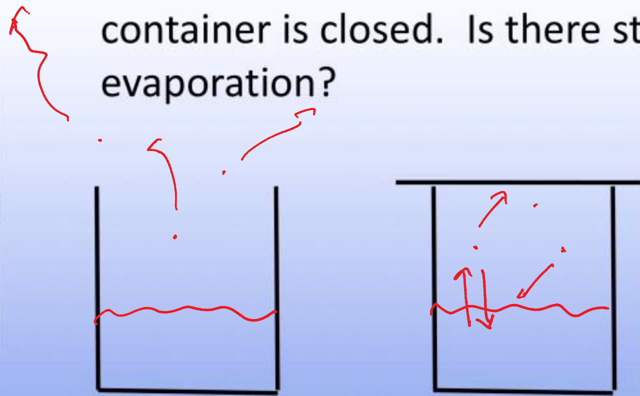
Poll: CLICKER QUESTION

Which distribution is a distribution at higher T?



Consider a case where the container is closed. Is there still evaporation?





We can measure how many molecules escape – Vapor Pressure

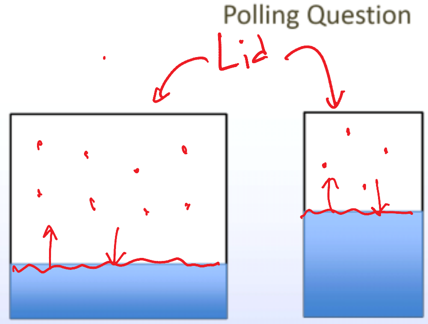
number of gas moles directly proportional to partial pressure

Dr. McCord's video on vapor pressure

http://www.youtube.com/watch?feature=player_embedded&v=gIXCxNbVO3k

Polling Question

You have two containers. (closed)
one has a total volume of 2 L and
one has a total volume of 1 L
Into each you place 500 mL of
liquid ether. They have the same
temperature



Which container has a higher pressure at equilibrium?

A. The 2 L container

B. The 1 L container

C. they are exactly the same

D. it depends on the temperature

$P = \frac{F}{A}$

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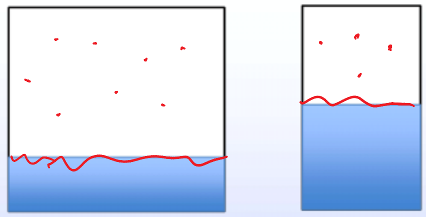


Which container has a the greater number of molecules of the ether in the gas phase?

A. The 2 L container
B. The 1 L container
C. they are exactly the same
D. it depends on the temperature

more molecules

same conc.
partial pressure

Look at this Data at 25° C

Compound	VP (Torr)	ΔH_{vap} (kJ mol^{-1})
Water	24	40.65
Diethyl Ether	545	27.4
Propane	7500	18.8

ΔH ↑ VP ↓

not linear

What is the relationship between VP and ΔH_{vap} ?

Look at this Data at 25° C

Compound	VP (Torr)	ΔH_{vap} (kJ mol^{-1})
Water	24	40.65
Diethyl Ether	545	27.4
Propane	7500	18.8
Butanol	7	51.6
Propanol	44	47.5
Ethanol	65	38.5
Methanol	127	37.8

R-OH

← more dispersion

What is the relationship between VP and ΔH_{vap} ?

At 25° C why does octane (C_8H_{18}) have a lower vapor pressure than hexane (C_6H_{14})?

A. octane has higher entropy

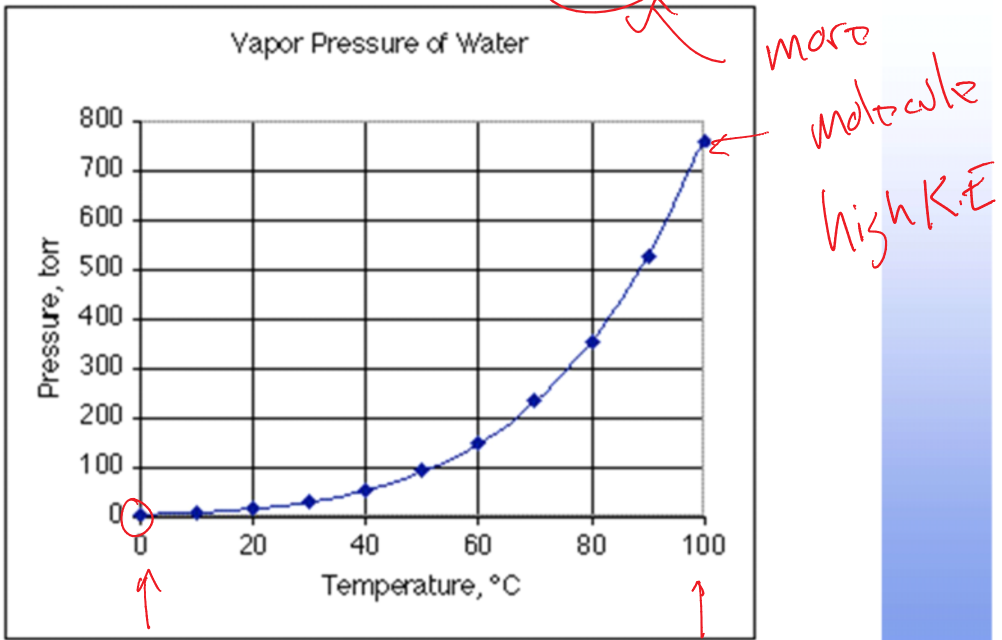
B. octane has stronger inter molecular forces

C. octane has a lower molecular weight

D. octane has a higher density

E. octane is an alcohol

How does VP change with T?

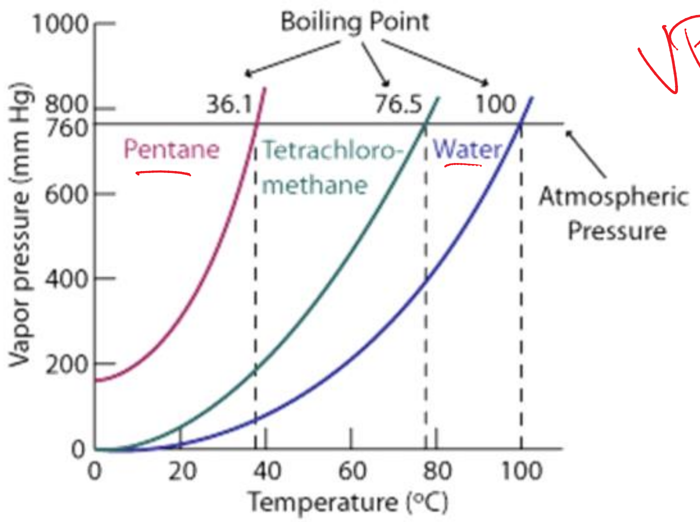


Polling Question

IS THE NORMAL BOILING POINT THE SAME FOR ALL LIQUIDS?

a) YES
b) NO

when VP = 1 atm



BOIL VP = TOTAL PRESSURE

Mathematical Relationship between VP and T

Vapor pressure of a liquid increases with increasing T

Clausius-Clapeyron equation

$$\ln\left(\frac{P_2}{P_1}\right) = \frac{\Delta H_{vap}}{R}\left(\frac{1}{T_1} - \frac{1}{T_2}\right)$$

T_1 P_1

T_2 P_2

$J\ mol^{-1}$

$8.314\ J K^{-1} mol^{-1}$

KELVIN

What did we learn just now?

Vapor Pressure is related to the "energy" of a substance.

VP is dependent on T.

VP is independent of amount of liquid present.

The stronger the IMFs, the bigger the difference in energy between the liquid and the gas (which has essentially no potential energy since the "molecules" are so far apart), the larger the $\Delta H_{vap,}$ the lower the VP.

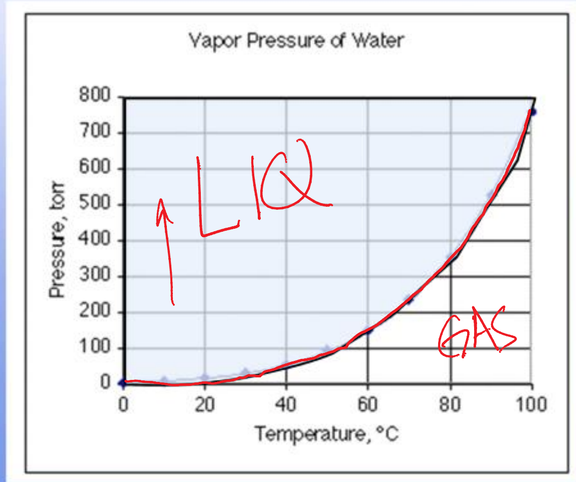
On the graph below, the line shows the pressure and temperatures at which the liquid and gas have the same free energy (both are stable).

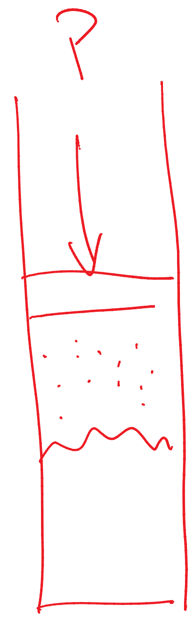
In the region that is colored blue, which phase do you think is stable?

A. Gas

B. Liquid

C. Niether



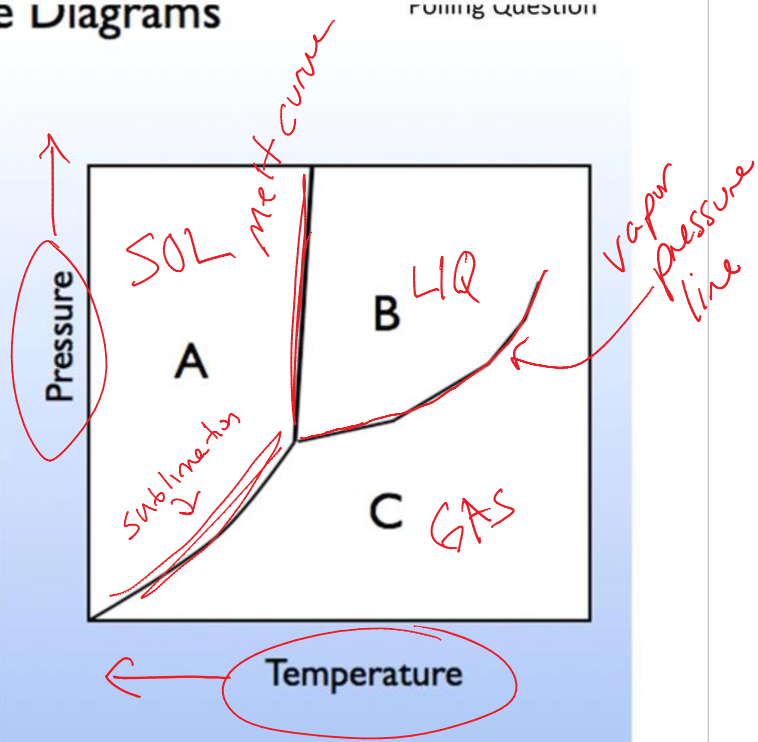


Phase Diagrams

Polling Question

The diagram on the right shows different phases for a compound as a function of temperature and pressure

What is the phase labeled "A"?



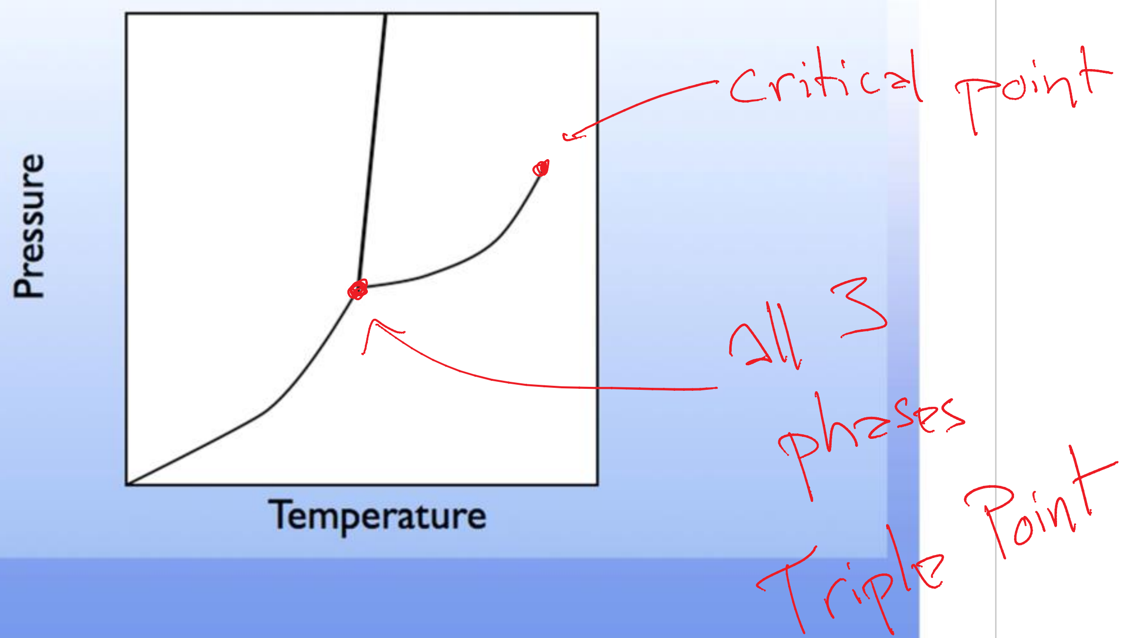
A. solid

B. liquid

C. gas

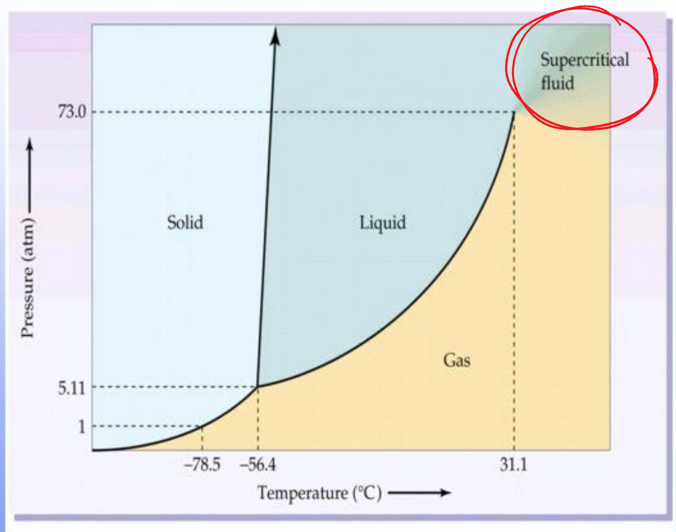
D. no way to know

Important Points



Polling Question

What is the temperature at the triple point?



A. 73.0 ° C

B. -78.5 ° C

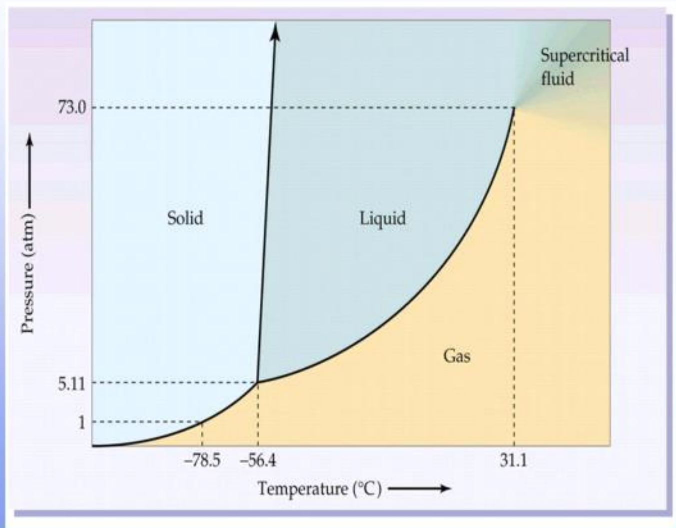
C. -56.4 ° C

D. 31.1 ° C

E. 5.11 ° C

Polling Question

At the triple point solid, liquid, and gas all have the same….



A. number of moles

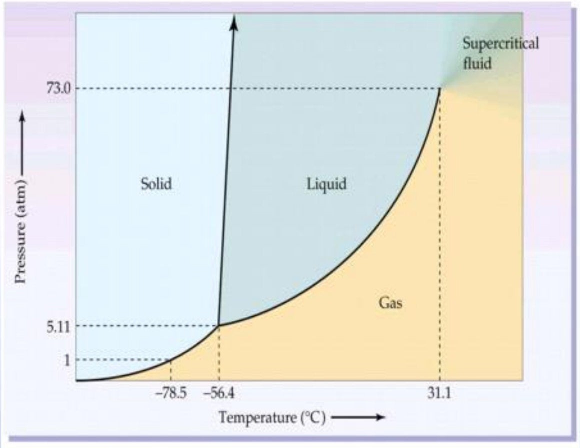
B. free energy

C. volume

D. density

E. entropy

Polling Question



This is the phase diagram for carbon dioxide.

Why does a piece of dry ice in the room sublime instead of melt?

A. Its intermolecular forces are too weak

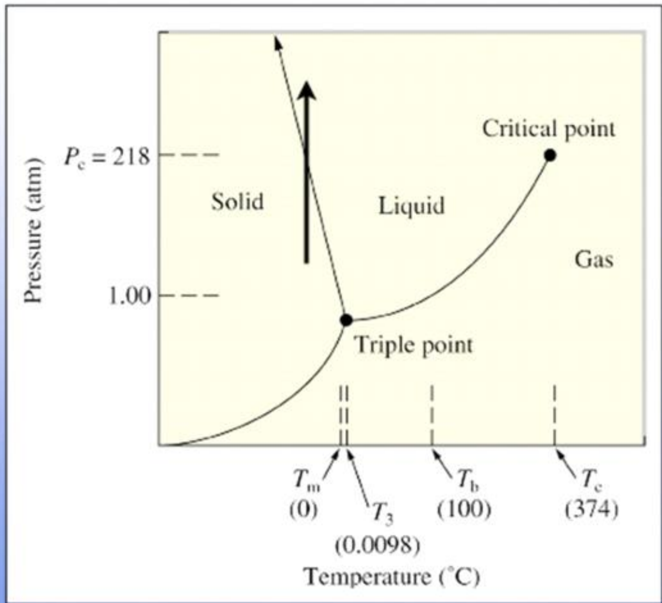
B. 1 atm is below the pressure at the triple point

C. At room temperature and pressure it is a gas

D. It can form a supercritical fluid

Polling Question

As the pressure is raised the melting point of water



A. decreases

B. increases

C. stays the same

What did we learn just now?

Boiling is when the vapor pressure equals the external pressure.

Normal "phase changes" occur at 1 atm, but phase change temperatures vary with pressure.

Phase changes are an equilibrium condition.

You can refer to a Phase Diagram to determine at what phase a particular substance will be in based on the external Pressure and Temperature.

What did we learn today?

Vapor Pressure is Temperature dependent.

When Vapor Pressure = External Pressure, liquid will boil.

The macroscopic property of boiling and melting can be explained by thinking of microscopic concept of the IMFs. The energy that goes into the system to cause the change is transferred to the potential energy of the system during the change.

Phase Diagrams are a chemist's and a chemical engineers friend.

LEARNING OUTCOMES

Understand how intermolecular forces and temperature affect vapor pressure.

Interpret phase diagrams and identify normal boiling and melting points, critical point and triple point.

Describe both boiling and evaporation (macroscopically and microscopically).