Lecture 7 CH131 Summer 1

Friday, May 31, 2019

The will be lab today, Friday, May 31

- Complete: Intermolecular forces
- Phase diagrams
  - Triple point YouTube video: http://goo.gl/4K1SR
  - Supercritical fluid YouTube video: http://goo.gl/xo2jU
- Liquid-vapor equilibrium: Vapor pressure and boiling
- Relative boiling points.

Next lecture: Begin ch11: Solutions: Colligative properties summary. Vapor pressure lowering (& boiling point elevation). Freezing point depression. Osmotic pressure.

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[TP] Which of the following are associated with intramolecular forces (forces within molecule)?

0% 1. Fog forms on a cold morning
0% 2. Wet clothes are hung out to dry
7% 3. Ice melts
7% 4. 1 and 2
50% 5. 1 and 3
0% 6. 2 and 3
0% 7. All of the above
36% 8. None of the above

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$2\,H-H + O=O \rightarrow 2\,H-O-H$

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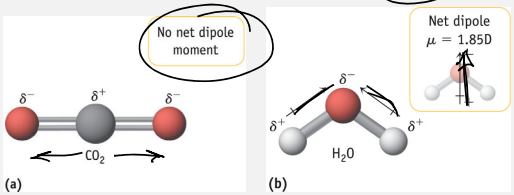
Molecular polarity

- If bond dipoles cancel, molecule is nonpolar
- If bond dipoles do not cancel, molecule is polar



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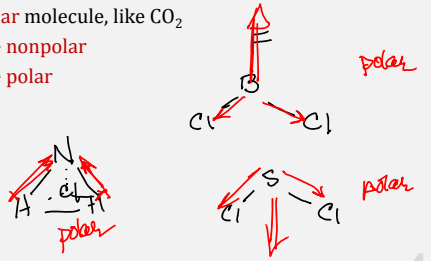
[TP] Which of the following molecules are not polar?

7% 1. $BFCl_2$, whose shape is trigonal-planar, like that of BF_3
0% 2. SCl_2, which is a bent molecule, like H_2O
0% 3. NH_2Cl, whose shape is trigonal-pyramidal, like that of NH_3
57% 4. OCS, which is a linear molecule, like CO_2
0% 5. All of the above are nonpolar
36% 6. All of the above are polar

polar

O–C–S



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[Quiz] Which of the following bonds is the most polar? CO, CTe, SnO or SnTe?

0% 1. CO
100% 2. SnO
0% 3. CTe
0% 4. SnTe

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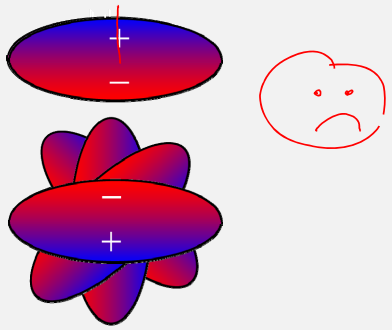
Dipole can be attractive or repulsive



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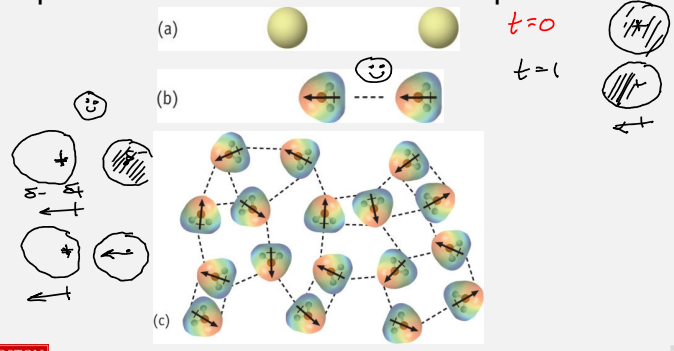
Dispersion forces due to induced dipoles



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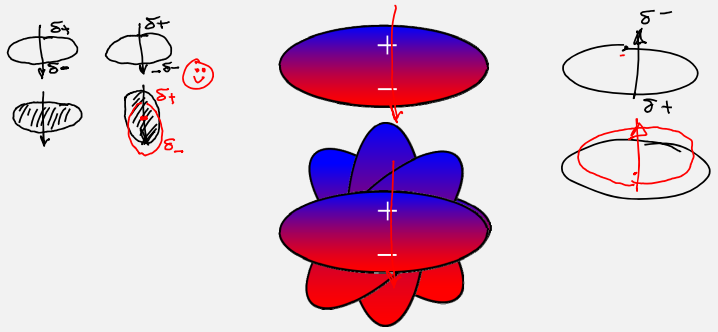
Dispersion always attractive



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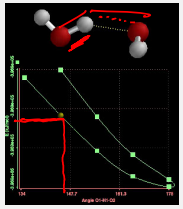
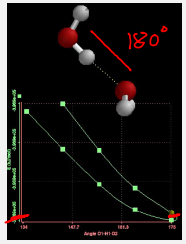
Hydrogen bonding is directional

N—H - - - :N—	O—H - - - :N—	F—H - - - :N—
N—H - - - :O—	O—H - - - :O—	F—H - - - :O—
N—H - - - :F—	O—H - - - :F—	F—H - - - :F—





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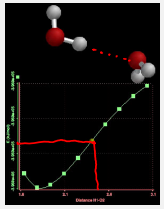
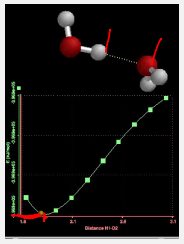
Hydrogen bonds are long

N—H - - - :N—	O—H - - - :N—	F—H - - - :N—
N—H - - - :O—	O—H - - - :O—	F—H - - - :O—
N—H - - - :F—	O—H - - - :F—	F—H - - - :F—





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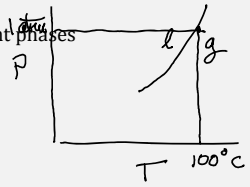
Phase diagrams

Lines of p versus T for which different phases are present at the same time.

That is, values of p and T for which different phases are in equilibrium.



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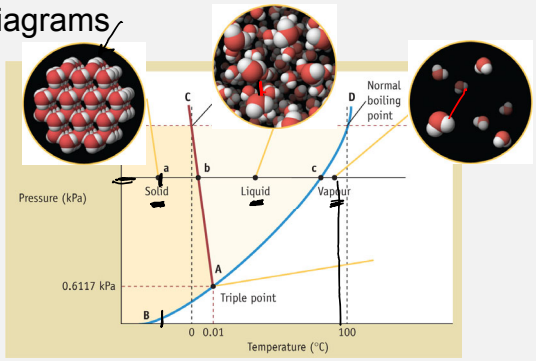
Phase diagrams



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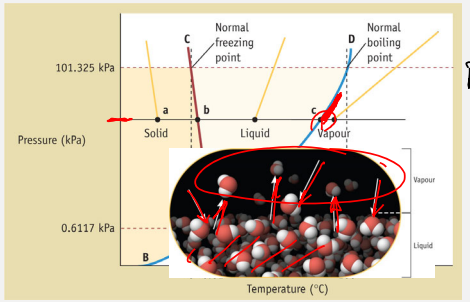
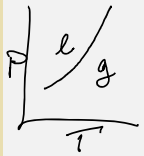
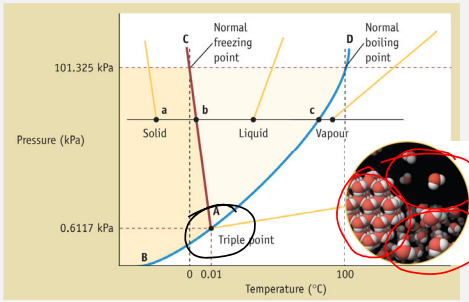
How about on blue line at 45 °C, point c?



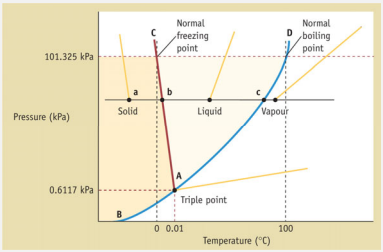


What about the intersection marked "A"



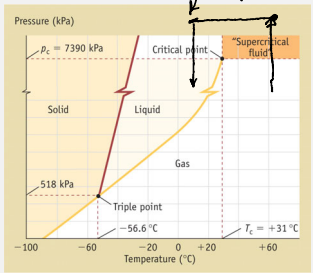
Triple point

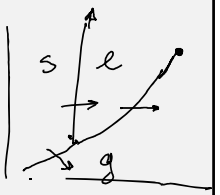
Liquid tert-butyl alcohol, $C(CH_3)_3OH$, can boil and freeze at the same time...
http://goo.gl/4K1SR



Supercritical fluid

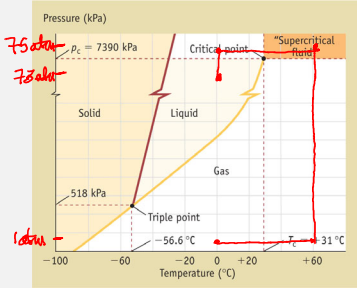
Supercritical transition of liquid Cl_2 ... http://goo.gl/xo2jU





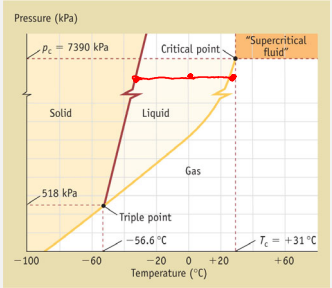
Changes of phase

CO_2 gas at 1 atm, 0 °C
is heated to 1 atm, 60 °C;
then compressed to 75 atm, 60 °C;
then cooled to 75 atm, 0 °C;
then expanded to 73 atm, 0 °C.
At this point, the CO_2 will be a …



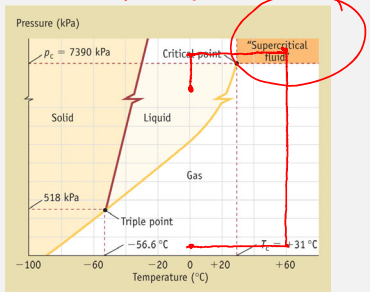
[TP] CO_2 gas at 1 atm, 0 °C
is heated to 1 atm, 60 °C;
then compressed to 75 atm, 60 °C;
then cooled to 75 atm, 0 °C;
then expanded to 73 atm, 0 °C.
At this point, the CO_2 will be a …

0% 1. gas
15% 2. supercritical fluid
85% 3. liquid
0% 4. solid



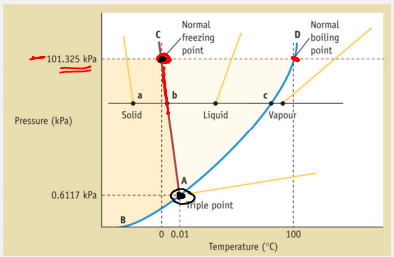
[Quiz] CO_2 at 1 atm, 0 °C
is heated to 1 atm, 60 °C;
then compressed to 75 atm, 60 °C;
then cooled to 75 atm, 0 °C;
then expanded to 73 atm, 0 °C.
At this point, the CO_2 will have undergone a phase transition …

27% 1. once
0% 2. twice
0% 3. three times
73% 4. None of the above

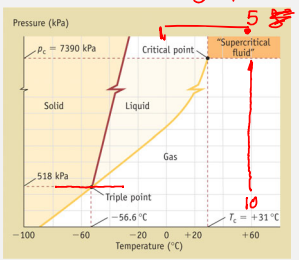


Phase diagrams are specific to each substance

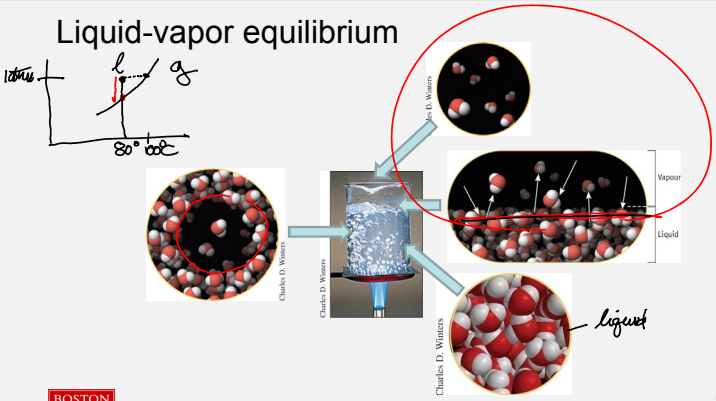
Water



CO_2



Liquid-vapor equilibrium



[TP] A bubble in a pot of boiling water contains…

0% 1. Only $O_2(g)$ and $H_2(g)$
60% 2. Only $H_2O(g)$
0% 3. Only air
20% 4. $H_2O(g)$ and air
13% 5. All of the above equally
7% 6. None of the above

Vapor pressure and boiling point

The normal boiling point is the temperature at which bubbles form at 1 atm.
What do you predict for relative boiling points of these substances?

Substance	Vapor pressure at 25 °C, kPa	Normal (1 atm) boiling point °C
Acetone, $CH_3C(O)CH_3$	30.8	
Diethyl ether, $(CH_3CH_2)_2O$	71.7	
Ethanol, CH_3CH_2OH	7.87	
Water, H_2O	3.17	100

[TP] The order of normal boiling points is …

80% 1. diethyl ether < acetone < ethanol
20% 2. ethanol < acetone < diethyl ether
0% 3. acetone < diethyl ether < ethanol
0% 4. diethyl ether < ethanol < acetone
0% 5. something else

Substance	Vapor pressure at 25 °C, kPa	Normal (1 atm) boiling point °C
Acetone, $CH_3C(O)CH_3$	30.8	
Diethyl ether, $(CH_3CH_2)_2O$	71.7	
Ethanol, CH_3CH_2OH	7.87	
Water, H_2O	3.17	100

Vapor pressure and boiling point

The normal boiling point is the temperature at which bubbles form at 1 atm.

What do you predict for relative boiling points of these substances?

Substance	Vapor pressure at 25 °C, kPa	Normal (1 atm) boiling point °C
Acetone, $CH_3C(O)CH_3$	3: 30.8	3: 56
Diethyl ether, $(CH_3CH_2)_2O$	4: 71.7	4: 35
Ethanol, CH_3CH_2OH	2: 7.87	2: 78
Water, H_2O	1: 3.17	1. 100

Vapor pressure and boiling point

The normal boiling point is the temperature at which bubbles form at 1 atm.

Sketch the four $l - g$ phase diagrams.

Substance	Vapor pressure at 25 °C, kPa	Normal (1 atm) boiling point °C
Acetone, $CH_3C(O)CH_3$	3: 30.8	3: 56
Diethyl ether, $(CH_3CH_2)_2O$	4: 71.7	4: 35
Ethanol, CH_3CH_2OH	2: 7.87	2: 78
Water, H_2O	1: 3.17	1. 100

Challenge: Normal boiling point, T_b

The normal boiling point is the temperature at which bubbles form at 1 atm.

Substance	T_b
Water (H_2O)	100 °C
Ammonia (NH_3)	−33.3 °C
Hydrogen chloride (HCl)	−84.8 °C
Methane (CH_4)	−161.5 °C
Nitrogen (N_2)	−195.8 °C

What do you predict for relative vapor pressures of these substances at −200 °C?

[Quiz] The substance with the lowest vapor pressure substances at −200 °C is ...

0% 1. CH_4
100% 2. NH_3
0% 3. HCl
0% 4. N_2

Substance	T_b
Water (H_2O)	100 °C
Ammonia (NH_3)	−33.3 °C
Hydrogen chloride (HCl)	−84.8 °C
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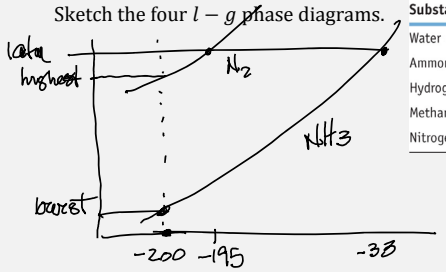
Nitrogen (N_2)	−195.8 °C

Challenge: Normal boiling point, T_b

The normal boiling point is the temperature at which bubbles form at 1 atm.

Sketch the four $l - g$ phase diagrams.



Substance	T_b
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29