

Units 3 & 4: A review

Reminders & Announcements

HW #4 is due on Fri. October 30th

Quiz 2 will be similar to HW #4 (cover units 3&4)

24 hours to complete

Release at 2PM on Monday, Nov. 9th due on Tuesday, Nov. 10th at 2PM

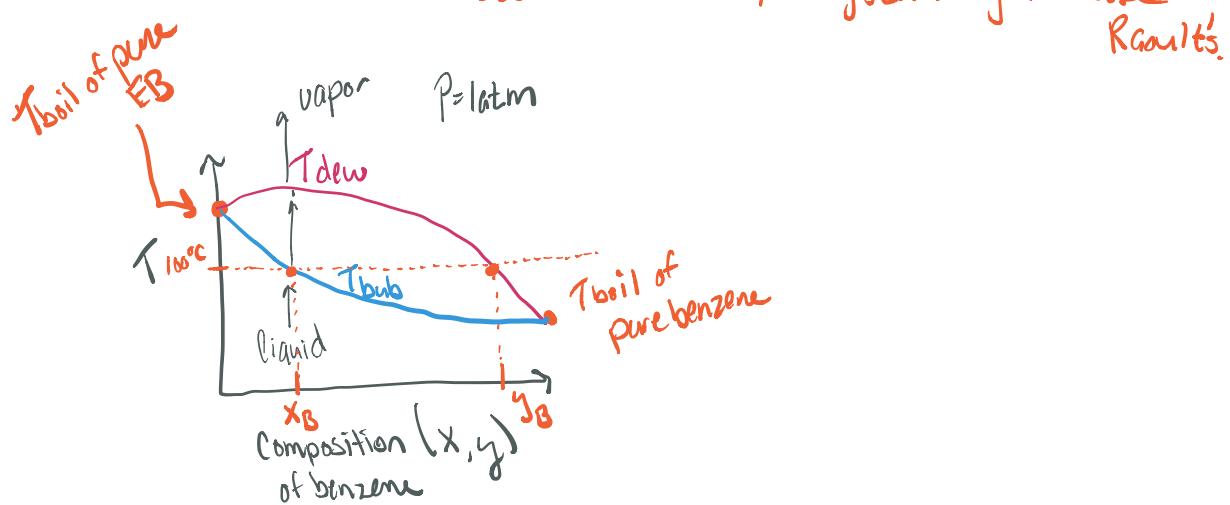
I will be available for questions during class hours and office hours

Day	Time	Location	Personnel
Monday	5-6 PM (ET)	Online	Aidan
Tuesday	6-7 PM (ET)	Online	Greer
Wednesday	8-9 PM (ET)	Online	Duval
Thursday	8-9 PM (ET)	Online	Duval

Multiphase, multispecies systems (in rLE)

Raoult's Law: can be used for any # of species, any P, any T
(within ideal gas assumptions) **But it takes a lot of time!**

T_{xy} Diagrams: can only be used at one specific pressure and for mixtures containing those specific species. It's super convenient if you have one for your system. **If you don't have access to one for your system - got to use Raoult's.**



Clarifications on Units 3+4

Conditions for using ideal gas law:

$$PV = nRT$$

$$PV = RT$$

\uparrow molar volume ($\frac{L}{mol}$)

1. No intermolecular interactions
2. High temperature
3. Low pressure
4. $V_{molecule} \ll V_{container}$
5. Perfectly elastic collisions

To know whether or not you can use ideal gas law:

$$\text{Calculate } \bar{V} \left(\frac{L}{mol} \right) = \frac{RT}{P}$$

if $\bar{V} > 5 \frac{L}{mol}$ diatomic gases \rightarrow ok!

if $\bar{V} > 20 \frac{L}{mol}$ other gases \rightarrow ok!

You are testing whether or not the gas molecules are spread out enough to not interact or collide.

In extreme cases: $\frac{L}{mol}$, \bar{V} is small.

Physically molecules are packed in tightly.

$\frac{L}{mol}$ \bar{V} is very big. A small number of molecules in a large volume, and they don't collide often or interact.

Mixtures of ideal gases: $\sum y_i P = P = \sum P_i$

If it's not ideal:

Compressibility factor equation of state

$$PV = nRT z$$
$$\hat{PV} = zRT$$

Contains species specific information

How to calculate/determine z ?

1a. Calculate $Tr = \frac{T}{T_c}$ system

$$Pr = \frac{P}{P_c}$$
 stream

for single species

T_c, P_c are critical properties and they are species specific!

non-ideal gases.

1b. calculate $Tr' = \frac{T}{T_c'}$

$$Pr' = \frac{P}{P_c'}$$

where

$$T_c' = \sum y_i T_{ci}$$

$$P_c' = \sum y_i P_{ci}$$

Because gas molecules are crowded and their identity matters!

2. Once you have (Tr, Pr) or (Tr', Pr')

read z from the ^{generalized} compressibility charts!

Raoult's Law [Empirical, lets us relate liquid phase composition to vapor phase composition]

Conditions for use:

1. no chemical reactions (phase change is ok)
2. vapor-liquid equilibrium
no vapor? No Raoult's Law!
no liquid? No Raoult's Law!
no eq? No Raoult's Law!
3. vapor phase behaves ideally
 $P=200\text{ atm}$? No Raoult's Law!
4. liquid phase behaves ideally

Raoult's Law for single or multi species VLE systems:

Single condensable component

$$y_i P = x_i P_i^{\text{sat}}$$

If only one species in liq. phase $x_i = 1$

$$y_i P = P_i^{\text{sat}}$$

We also know $y_i P = P_i$ so...

$$P_i = P_i^{\text{sat}}$$

In this single condensable component example, the partial pressure of species i equals the saturation pressure of species i

Single vaporizable component

$$y_i P = x_i P_i^{\text{sat}}$$

If only species is volatile $y_i = 1$

$$P = x_i P_i^{\text{sat}} = P_i$$

$$P_i \neq P_i^{\text{sat}}$$

multiple condensable components

$$y_i P = x_i P_i^{\text{sat}}$$

We can still say $y_i P = P$

$$P_i = y_i P = x_i P_i^{\text{sat}}$$

$$P_i \neq P_i^{\text{sat}}$$

We have multiple species in both phases, so we can rearrange + sum up either $x_i = 1$ or $y_i = 1$

$$\sum y_i = \frac{\sum x_i P_i^{\text{sat}}}{P} = 1$$

We could also rearrange and solve for x_i

$$\sum x_i = \sum \frac{y_i P}{P_i^{\text{sat}}} = 1$$

Finally, we can treat the vapor phase as a mixture of ideal gases.

$$P_{\text{tot}} = \sum y_i P = \sum x_i P_i^{\text{sat}}$$