Chem 108: Lab
Week 12

Sign in

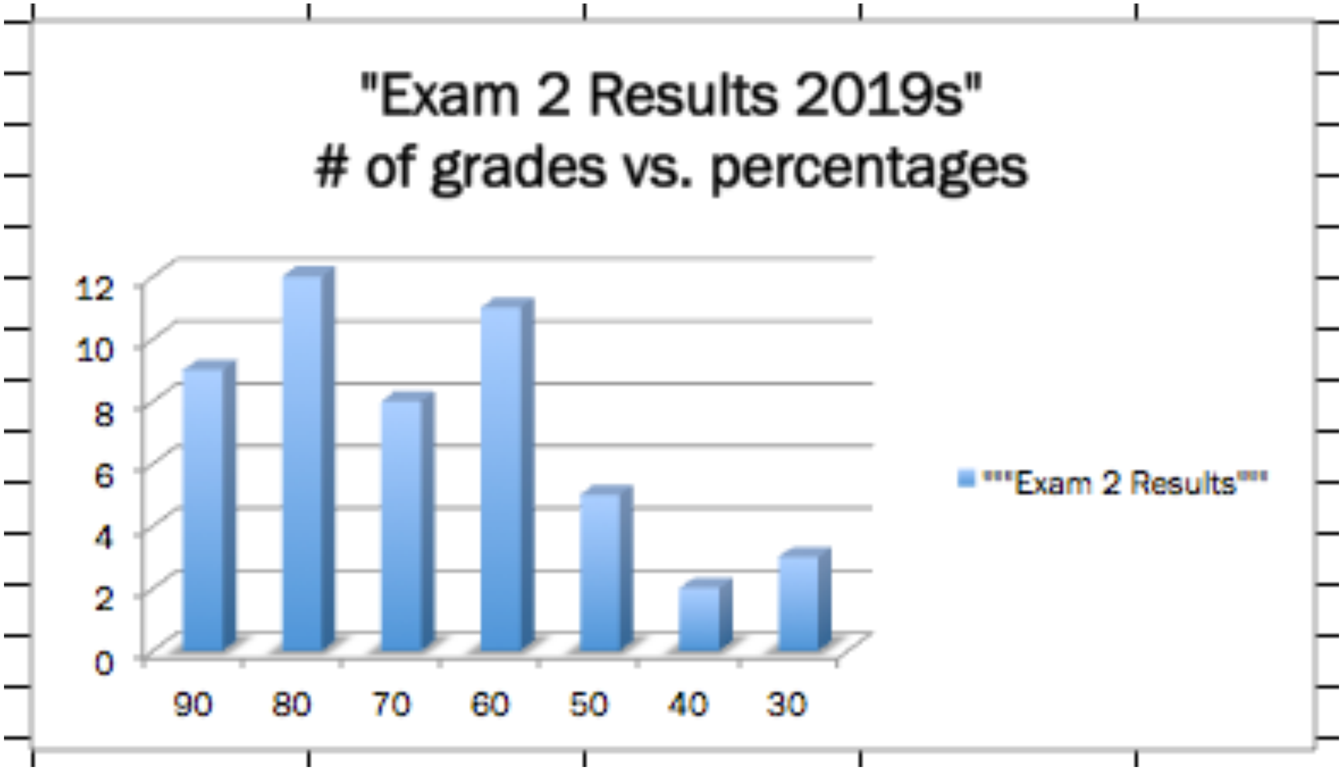
Alcohol Distillation

To do with your Fermentation partner:

Turn in 7-Solution Report form

and

Post Lab Questions



avg	72.3%	%
std dev +/-	17.6	
Normalization	125	

7 Solutions Report pp. 76-80 & Post Lab Questions Due Today

Chem 108 / Dr. Rusay

Names: ____________________

Post Lab Questions: 7-Solution Problem
http://chemconnections.org/general/chem120/solutions-mixes.108.html

1. If the maximum concentration of a saturated sodium chloride solution is 5.9M, how many liters of water would a Peruvian salt farmer need to process in order to produce one 50.0 kilogram bag of salt. (Assume that there are no other salts present. Show your calculation.)

2. If the Peruvian water has a TDS of 10.0 grams per liter of water, would it be within the safe limits of drinking water by U.S. standards? (Explain your answer.)

3. The following table includes chemicals that may be found in tap water. Complete the table for allowable limits.

	Allowable Limit
Nitrate	
Fluoride	
Mercury	
Lead	

4. What were the highest tested levels of lead in Flint Michigan's drinking water during the crisis?

5. What was the length of time that Flint residents were exposed to higher than allowable levels of lead?

6. What are the neurological effects of lead exposure particularly on children and infants?

QUESTION

Solutions: molarity & volume → mass

How many grams of NaCl are contained in 350. mL of a 0.250 M solution of sodium chloride?

A) 41.7 g
B) 5.11 g
C) 14.6 g
D) 87.5 g
E) None of these

ANSWER

B) 5.11 g

Seven Solutions Post Lab Questions
http://chemconnections.org/general/chem120/solutions-mixes.108.html

Volume (L) times concentration (mol/L) gives moles. Moles are then converted to grams multiplying by the molar mass.

Chemical Reactions

To DO Today

Separating the Ethanol Produced

Fermentation / Distillation pp.63-67

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http://www.piney.com/BabNinkasi.html)

http://chemconnections.org/general/chem108/Beer-Ninkasi-Dana%20Garves.pdf

Biological Reactions: Enzyme Catalysts

Fermentation / Distillation

Career ladder

Dana Garves

This bench chemist built her own business around the craft beer boom

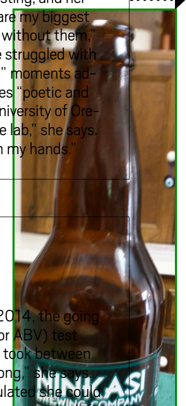
CRAIG BETTENHAUSEN, C&EN WASHINGTON

Know a chemist with an interesting career path? Tell C&EN about it at **cenm.ag/careerladder.**

2006

An interest in chemistry

Dana Garves started pursuing science in secret. She joined her high school's Science Olympiad team without telling her parents. Then one day, she needed help with an event. "I had to blindside my mom: 'Hey, so, I'm in the Science Olympiad. And I'm also the president. And also, can you chaperone?' " Garves wasn't embarrassed, but science wasn't a big part of her family's daily lives before that. Her mother worked in video game testing, and her father was a mechanic for Boeing. "My parents are my biggest supporters, and I would not be where I am today without them," she says. Chemistry was one of the subjects she struggled with the most in high school, but she found the "Aha!" moments addictive and the interactions of subatomic particles "poetic and beautiful." Garves majored in chemistry at the University of Oregon. "I loved the analytical side; I love being in the lab," she says. "I've always loved being on a bench working with my hands."



2010

Industry experience

As an undergrad, Garves did research on how green chemistry principles can be used in the classroom, with an eye toward a career in teaching. But she soon found that "the teachers I liked the most in college all had industry experience." So after graduation, she landed a job with a water quality testing lab in Oregon. "I was bored to tears," she says. But the experience gave her an appreciation for quality control. "I fell in love with the rigidness of it." She knew she liked QC and liked chemistry, but how could she make it interesting?

2011

A move to the beer world

Searching Craigslist, Garves found an unattributed opening in the QC lab of a beer brewery. She applied through the listing and also researched every brewery in the area until she found one, Ninkasi Brewing, with a matching opening advertised. She sent her materials to the company directly, then "went in person and pestered them until they gave me an interview," she says. Garves got the job and spent four years building Ninkasi's chemistry and sensory labs. She also got to work on exciting side projects, such as when the firm sent yeast into orbit and found it could survive the rigors of space travel (right). Around 2012, other nearby breweries starting asking for her help. Soon, requests for analysis favors started arriving by mail, and brewers from across the country would visit with samples in need of testing.

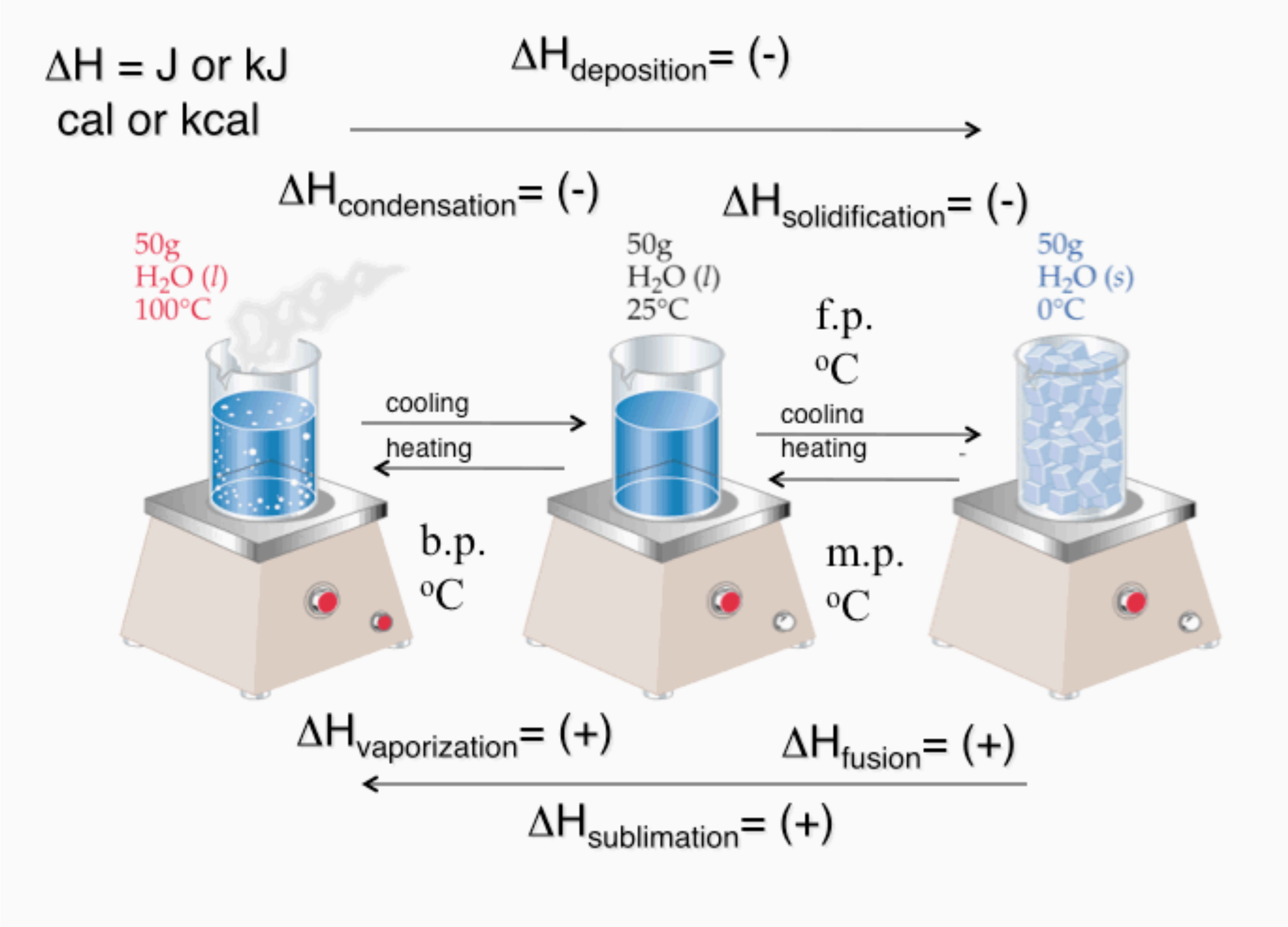
Today

Brewing entrepreneur

Garves saw an opportunity in beer analysis. In 2014, the going rate for an alcohol percent (alcohol by volume, or ABV) test at contract labs was around \$200, and results took between five days and two weeks to arrive. "That's too long," she says. "That beer is already in pint glasses." She calculated she could do it much faster and for just \$20. So that same year, she left Ninkasi, cashed out her 401(k) to raise capital, and started Oregon BrewLab in her garage. "It was very scary. Working for a larger brewery is a pretty cushy job," Garves says. "I had to adjust to buying beer again, for one thing." At the end of the first year, she had just 50 clients and had to bartend and work odd jobs to make ends meet. Four years in, she has more than 200 clients and says she may hire help. But any assistant will be in the office; she wants to do the bench work herself.

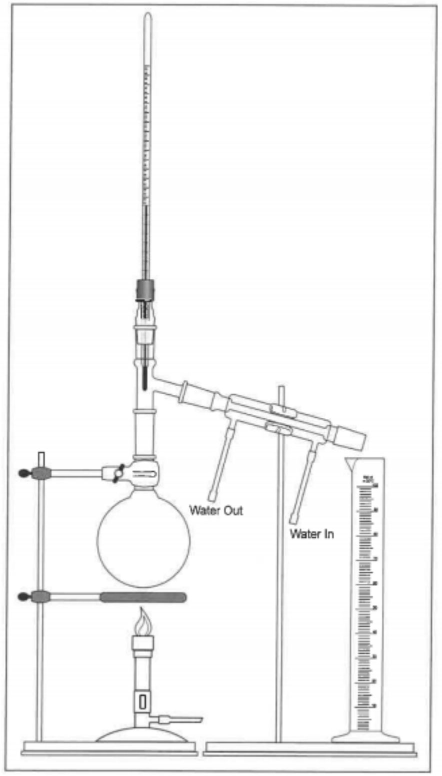
CREDIT: MICHELLE LEIS FOLEY (2010); LISA MCAULIFFE (2011); KILEY GWYNN (TODAY)

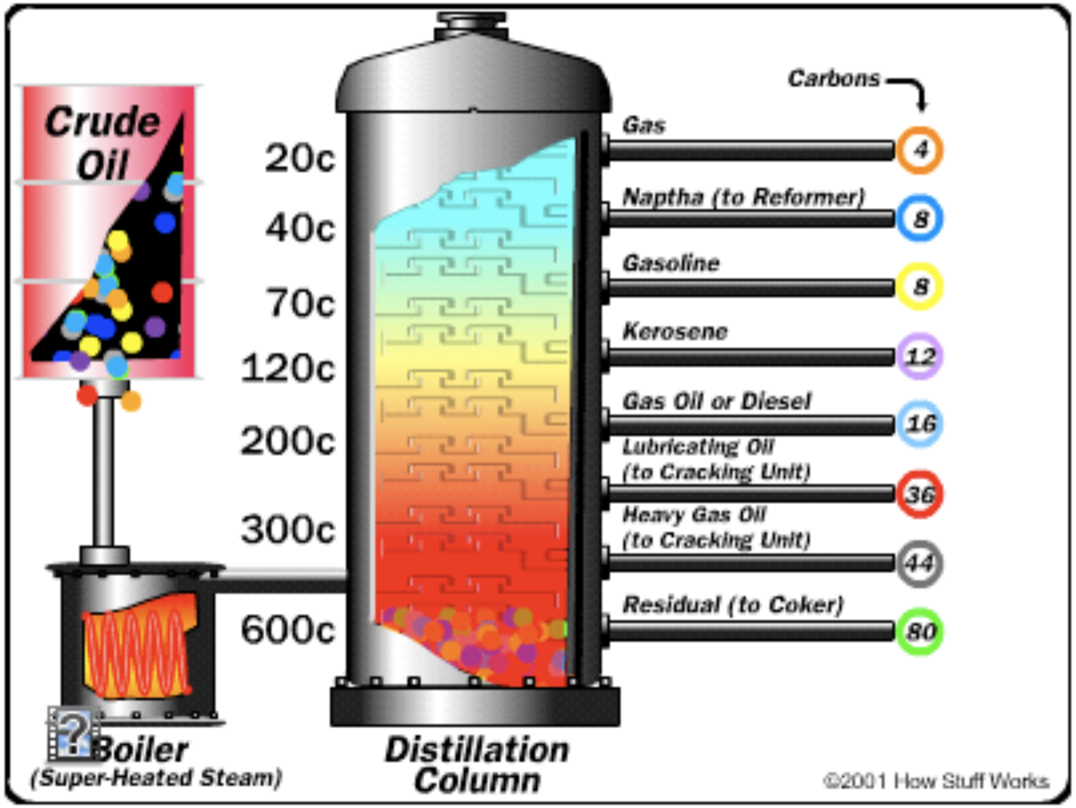
Energy: Heat: Enthalpy (ΔH)



Distillation

http://chemconnections.org/general/movies/html-swf/oil-refining.swf





Oil Refining:

http://science.howstuffworks.com/oil-refining4.htm

QUESTION

Answer either: A) endothermic, or: B) exothermic for each of the following 5 changes of physical state.

1. Fusion
2. Vaporization

A) endothermic

3. Condensation
4. Sublimation
5. Liquid → Solid

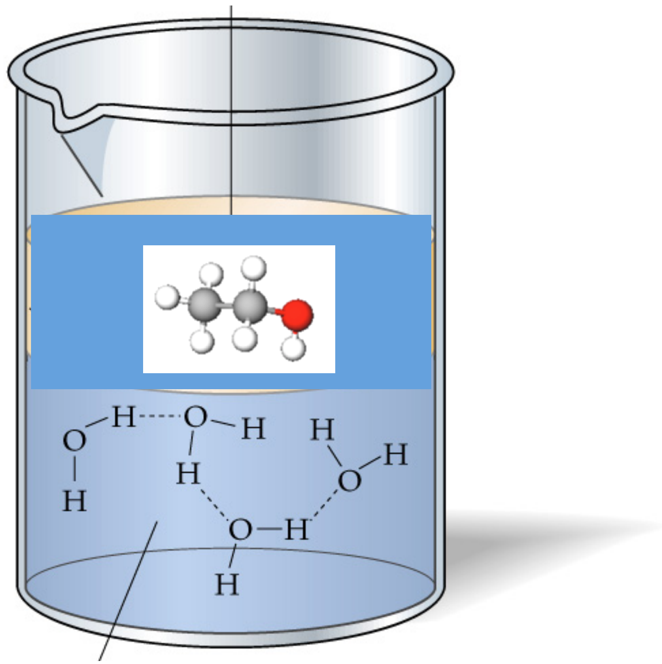
Distillation involves heating.

How could distillation be done @ lower temperatures?

One of many products being sold.

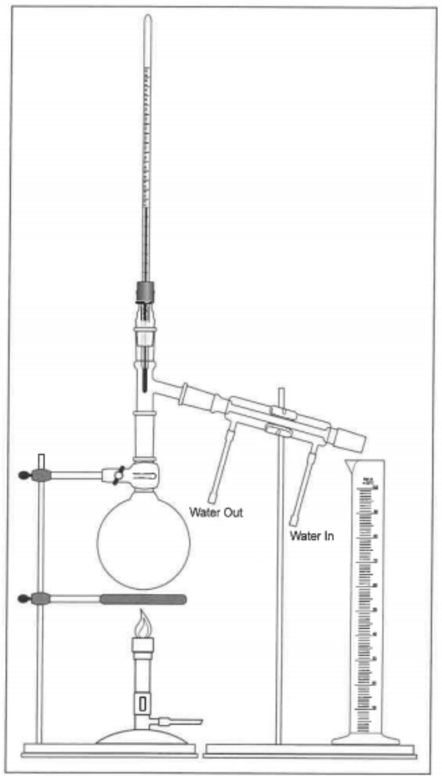
Water : "The Universal" Solvent

The ethanol product is **miscible** in water and both vaporize when the solution is distilled.



Theoretical & Percent Yield

http://chemconnections.org/general/movies/html-swf/oil-refining.swf



Density and Percent Alcohol of the Distillate

While the distillate is cooling weigh a clean dry vial and cap or small beaker and record the mass. Obtain a 20 or 25 mL pipet (each partner should have a vial or small beaker and each partner must use a different volume) and rinse it thoroughly with deionized water. Draw distillate into the pipet until the bulb is about one–third full. Rinse all parts of the pipet with the distillate and return the it to the distillate in the flask. You don't want to discard any alcohol at this point. Rinse the pipet a second time with distillate and return it to the flask. Pipet 20 or 25 mL of distillate (depending on the volume of your pipet) into the weighed vial and cap the vial or into a small beaker. Weigh the vial or beaker and contents and record the mass. If your density and your partner's don't agree within 0.005 g/mL repeat the procedure. When you have two densities that agree, record your partner's density and average them. Determine the percent alcohol to 0.1 % from the table of densities.

The ethanol produced in the fermentation is distilled along with the water used. The liquid collected is ethanol mixed in with the water, which is the solvent. The amount dissolved will be calculated by experimentally determining the solution's density.

What is a solution's concentration?

Solution Concentrations

Concentration is a measure of the amount of solute dissolved.

$$\text{molarity} = \text{M} = \frac{\text{moles solute}}{\text{liters solution}}$$

Some other common units include percentage by mass, percentage by volume, (which relates to alcoholic proof), parts per million, parts per billion, and molality. The definition of each provides the basis for calculations with that unit.

$$\%\text{ by mass} = \frac{\text{mass solute}}{\text{mass solution}} \times 100$$

$$\%\text{ by volume} = \frac{\text{volume solute}}{\text{volume solution}} \times 100$$

[Proof = % by volume x 2]

$$\text{parts per million} = \text{ppm} = \frac{\text{mass solute}}{\text{mass solution}} \times 10^6$$

$$\text{parts per billion} = \text{ppb} = \frac{\text{mass solute}}{\text{mass solution}} \times 10^9$$

$$\text{molality} = \text{m} = \frac{\text{moles solute}}{\text{kilograms solvent}}$$

Solution Concentrations

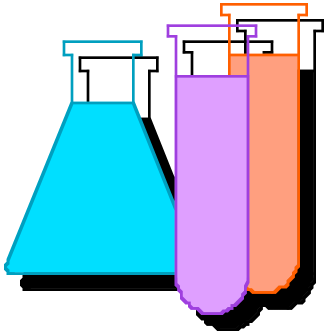
- Concentration in mass percent is common.

Mass % = Mass solute / [Mass solute + Mass solvent] x100

- What is the mass % of 65.0 g of glucose dissolved in 135 g of water?

Mass % = 65.0 g / [65.0 + 135]g x 100

= 32.5 %



% Ethanol from Density

PERCENT ETHANOL FOR VARIOUS DENSITIES

% ethanol by mass	Density (g/mL)	% ethanol by mass	Density (g/mL)	% ethanol by mass	Density (g/mL)
0.0	0.998	35.0	0.945	69.0	0.870
1.0	0.996	36.0	0.943	70.0	0.868
2.0	0.995	37.0	0.941	71.0	0.865
3.0	0.993	38.0	0.939	72.0	0.863
4.0	0.991	39.0	0.937	73.0	0.860
5.0	0.989	40.0	0.935	74.0	0.858
6.0	0.988	41.0	0.933	75.0	0.856
7.0	0.986	42.0	0.931	76.0	0.853
8.0	0.985	43.0	0.929	77.0	0.851
9.0	0.983	44.0	0.927	78.0	0.848
10.0	0.982	45.0	0.925	79.0	0.846
11.0	0.980	46.0	0.923	80.0	0.843
12.0	0.979	47.0	0.920	81.0	0.841
13.0	0.978	48.0	0.918	82.0	0.838
14.0	0.976	49.0	0.916	83.0	0.836
15.0	0.975	50.0	0.914	84.0	0.833
16.0	0.974	51.0	0.912	85.0	0.831
17.0	0.973	52.0	0.909	86.0	0.828
18.0	0.971	53.0	0.907	87.0	0.826
19.0	0.970	54.0	0.905	88.0	0.823
20.0	0.969	55.0	0.903	89.0	0.821
21.0	0.967	56.0	0.900	90.0	0.818
22.0	0.966	57.0	0.898	91.0	0.815
23.0	0.965	58.0	0.896	92.0	0.813
24.0	0.963	59.0	0.893	93.0	0.810
25.0	0.962	60.0	0.891	94.0	0.807
26.0	0.960	61.0	0.889	95.0	0.804
27.0	0.959	62.0	0.887	96.0	0.801
28.0	0.957	63.0	0.884	97.0	0.798
29.0	0.955	64.0	0.882	98.0	0.795
30.0	0.954	65.0	0.879	99.0	0.792
31.0	0.952	66.0	0.877	100.0	0.789
32.0	0.950	67.0	0.875		
33.0	0.949	68.0	0.872		
34.0	0.947				

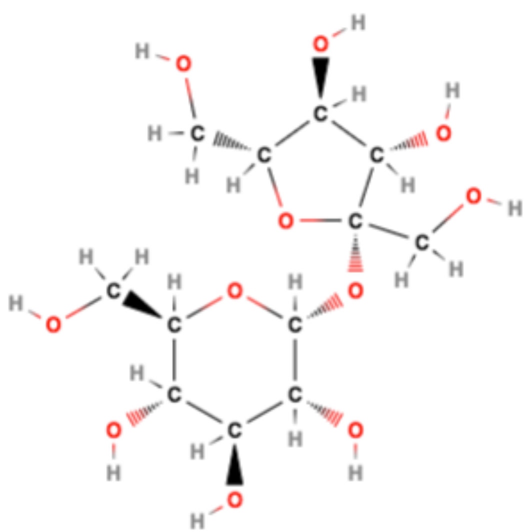
Calculations

Determination of Percent Yield

From the density, volume, and percent alcohol of the distillate, calculate the actual yield in grams of ethanol. From the balanced equation for the reaction, given in the background, and the mass of sucrose fermented, calculate the theoretical yield. Finally, calculate the percent that the actual yield is of the theoretical.

$$C_{12}H_{22}O_{11} + H_2O \rightarrow 4\ C_2H_5OH + 4\ CO_2$$

sucrose *ethanol*



Example

Reactant:

	g (grams)
Mass, sucrose + container	
- Mass container (Tare)	
Mass, sucrose	24.55 g

Simple Distillation:

Temperature Range	°C to °C
Volume of Distillate Collected (mL)	52.2 mL

Density, Mass & Percent Yield of Alcohol in the Distillate: 9.90 g / 10.00 mL

Volume of pipet (mL)	
Mass of beaker + distillate (grams)	
Mass of beaker (grams)	
Mass of distillate (grams)	
Density (g/mL)	0.990 g/mL
% Percent ethyl alcohol (from Table)	
Total mass of ethyl alcohol produced (calculated)	
% Percent Yield ethyl alcohol (calculated)	

4.5 %

0.990 g/mL

PERCENT ETHANOL FOR VARIOUS DENSITIES

% ethanol by mass	Density (g/mL)	% ethanol by mass	Density (g/mL)	% ethanol by mass	Density (g/m L)
0.0	0.998	35.0	0.945	69.0	0.870
1.0	0.996	36.0	0.943	70.0	0.868
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31.0	0.952	66.0	0.877	100.0	0.789
32.0	0.950	67.0	0.875		
33.0	0.949	68.0	0.872		

Example

24.55 g

52.2 mL

Theoretical Yield Calculation

24.55 g *? g* (theoretical)

$$C_{12}H_{22}O_{11} + H_2O \rightarrow 4\ C_2H_5OH + 4\ CO_2$$

sucrose *ethanol*

Molar mass = 342.3 g/mol Molar mass = 46.07 g/mol

? mol *sucrose* = 24.55 g / 342.3 g/mol
= 0.07172 mol

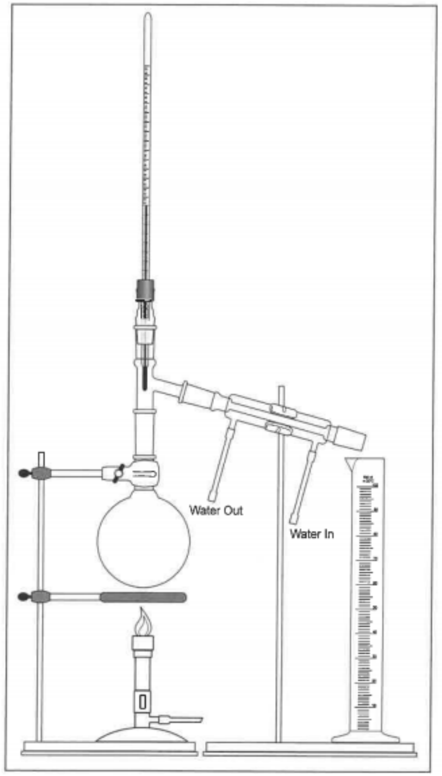
? mol C_2H_5OH = 4 x mol *sucrose*
= 0.2869 mol

? g (theoretical) = mol C_2H_5OH x 46.07 g/mol
= 13.22 g

? g (actual) = [*4.5 %* ,that is: 4.5/100] x *52.2 mL x 0.990 g/mL*
= 2.33g

% Yield = g (actual) / g (theoretical) x 100 = 17.6 %

Theoretical & Percent Yield

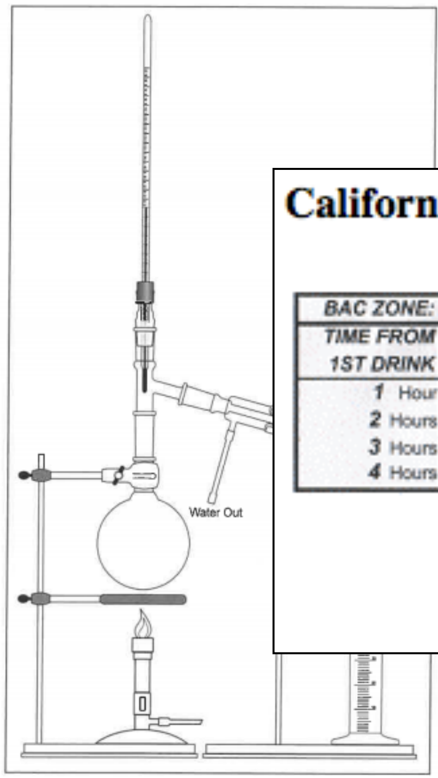


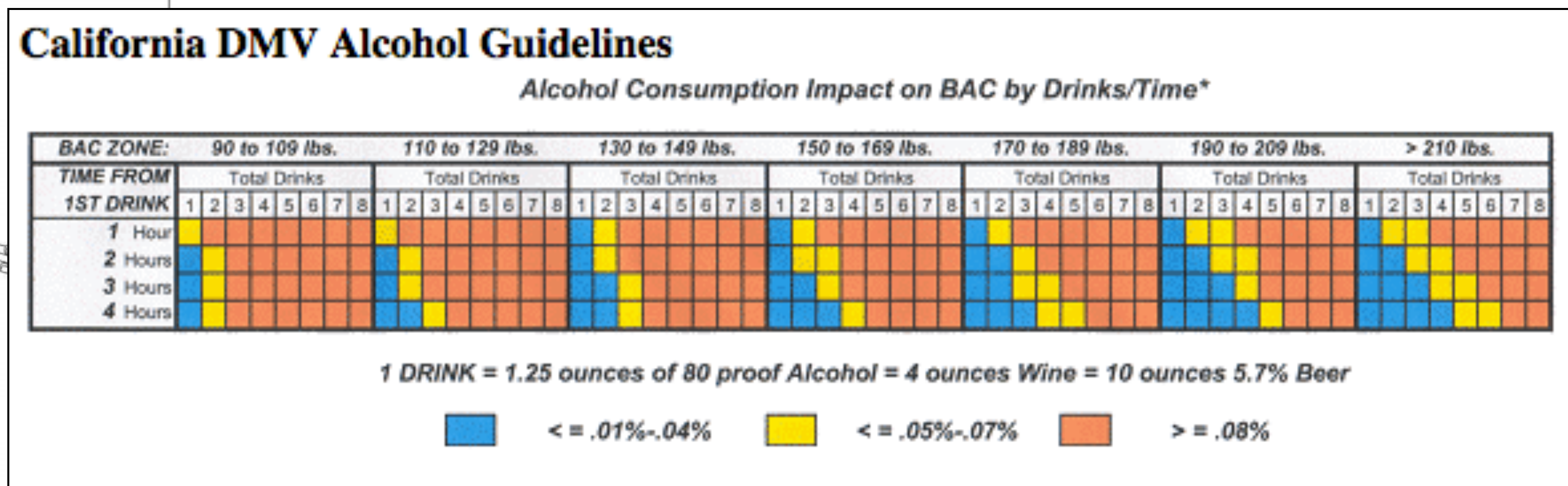
Experimentation:

Doing:
Laboratory Manual Fermentation-Distillation Procedure pp. 63-64; Report Form pp. 66-67; DUE: Next Week (Show Dr. R. distillate before disposing down the drain & have data initialed before leaving lab today.)
POST LAB Questions DUE: Next Week Pick up Handout

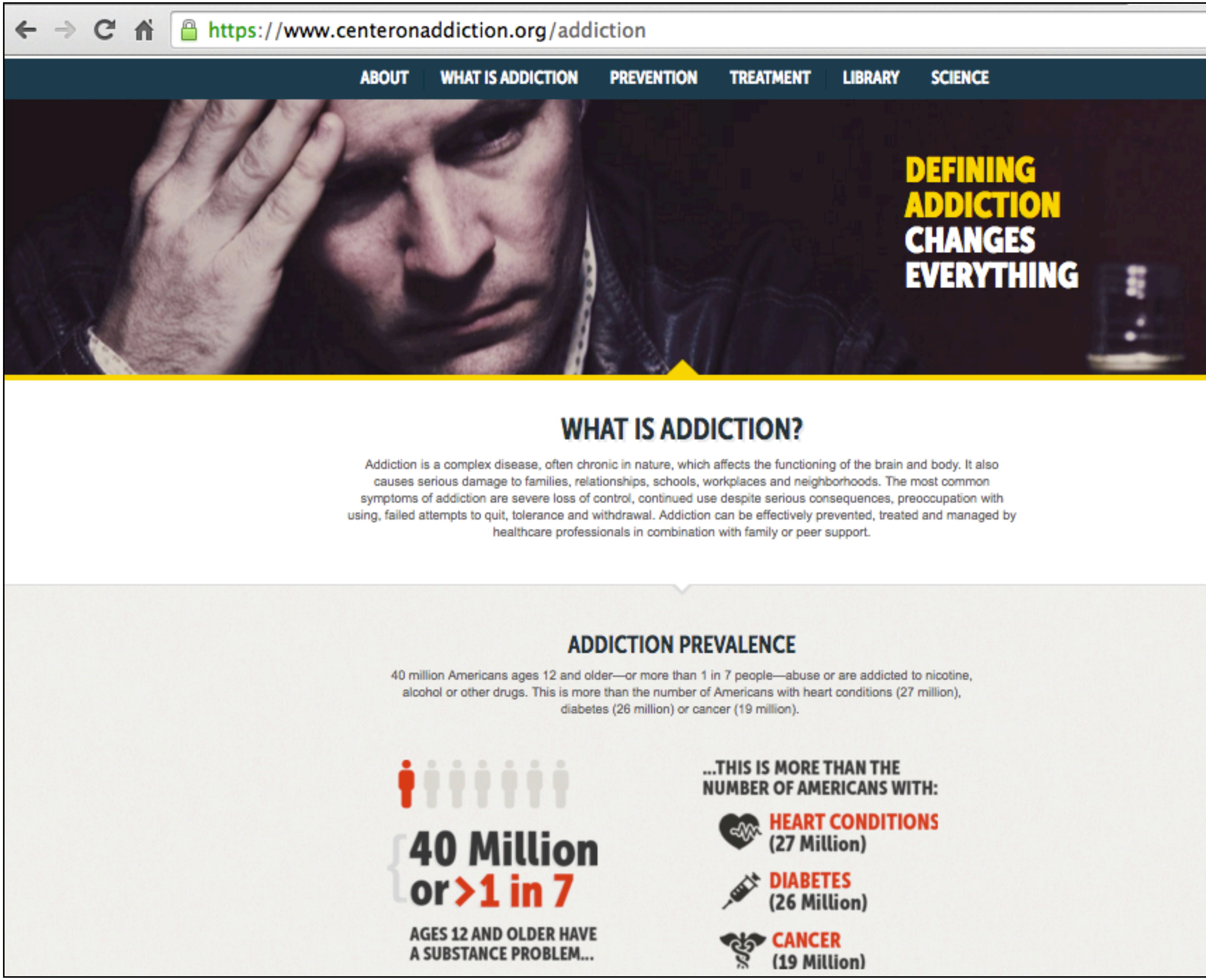
POST LAB Questions DUE: Next Week

http://chemconnections.org/general/chem120/
ethanol-ques-108.htm





https://www.youtube.com/watch?v=P--6LEbksds



https://www.centeronaddiction.org/

POST LAB Questions; Handout

Turn in Next Week

http://chemconnections.org/general/chem120/ethanol-ques-108.htm

Chem 108 / Dr. Rusay

Name: ____________________

Ethanol Post Lab Questions

Using the Internet & Web Reading List
(http://chemconnections.org/general/chem120/alc-2010.html)

1. Explain the importance of the protein zymase in the production of ethanol in a sentence or two.

2. What year was ethanol first used in an internal combustion engine?

3. Show your calculations for the following problems.

A) How much energy (kJ) could be produced from the oxidation of one gallon of pure ethanol (d =0.789 g/mL)? The amount of energy produced per mole of ethanol is -1367.6 ± 0.3 kJ/mol.

B) How much energy (kJ) could be produced from the combustion of 1 gallon of isooctane (C_8H_{18} , gasoline), d= 0.69 g/mL? The amount of energy produced per mole of isooctane is –5460.0 kJ/mol.