Chem 108: Lab

Week 12

Sign in

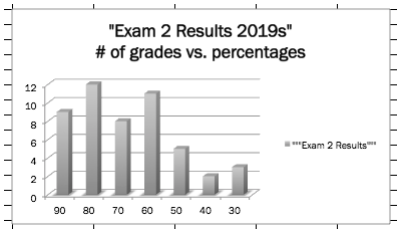
Alcohol Distillation

To do with your Fermentation partner:

Turn in 7-Solution Report form

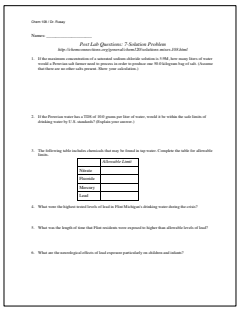
and

Post Lab Questions



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

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



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

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

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

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

Career ladder

Dana Garves

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

An interest in chemistry

Industry experience

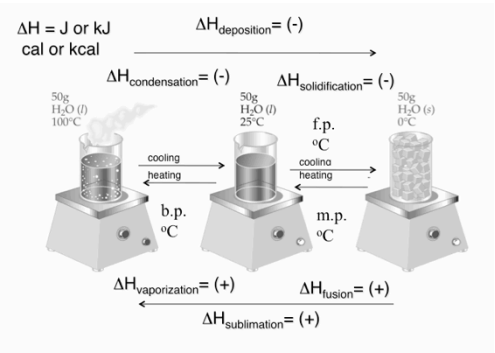
Brewing entrepreneur

A move to the beer world

Biological Reactions: Enzyme Catalysts

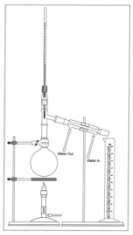
Fermentation / Distillation

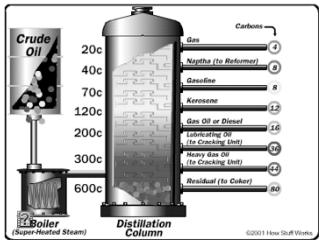
Energy: Heat: Enthalpy (ΔH)



Distillation

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





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

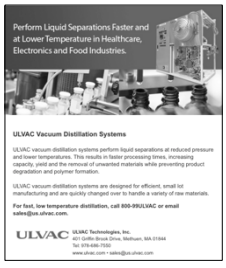
QUESTION

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.

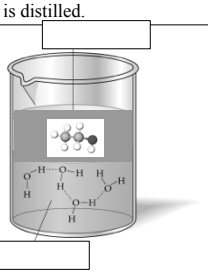
How could distillation be done @ lower temperatures?



One of many products being sold.

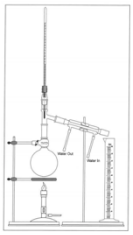
Water : "The Universal" Solvent

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.

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

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]

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

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

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

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				

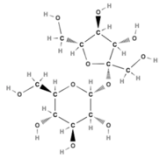
Calculations

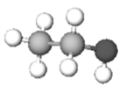
Determination of Percent Yield

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 / 10.00mL

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/mL)
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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

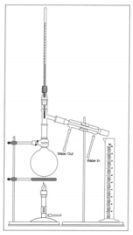
? mol C_2H_5OH = 4 x mol *sucrose* = 0.2869 mol

? 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

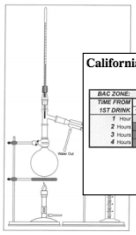


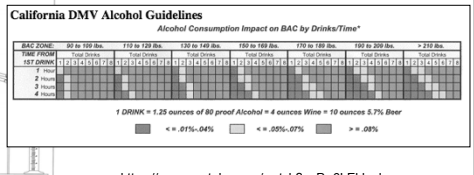
Experimentation:

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

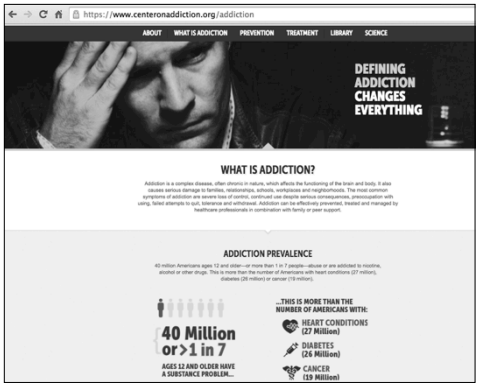
POST LAB Questions DUE: Next Week

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