Chem 108: Lab

Week 7

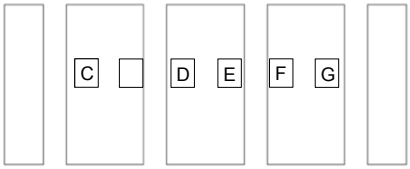
Experiment:

What's My Formula?

If you did not pick up Exam 1 yet , get yours from the Pendaflex file.

Sign in; Check Group # on roster, and go to the location below.

Front of Lab



Work with the same group from last week's lab.

Chem 108: Lab

Week 7

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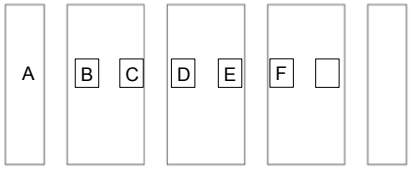
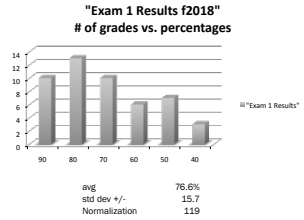


Work with the same group from last week's lab.

Exam 1

Divide your exam raw score total by 119

Percentages are plotted below



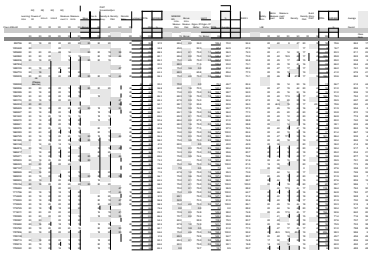
avg	76.6%
std dev +/-	15.7
Normalization	119

CLASS Grades

Linked from Calendar (Exam 1)

Come to office hours or make an appointment to correct any errors or ask any questions

http://chemconnections.org/general/chem108/Exam%201-f2018.htm



Experiment 4: Hydrates

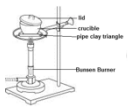
DUE Today

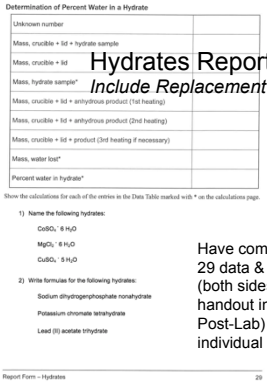
- Report Form: *One form for each lab partner who did the unknown from last week are both to be turned in; Place your partner's name next to yours & staple forms together.*
  - Check sig figs are correct and units included
  - Show calculations
  - Answer post lab question; show calculation.

Include completed Replacement Page (pg. 29)

Nomenclature:

Entire Group is to turn in one set of Lab manual pages 109-114 with the names of only those who contributed. Group does not be your assigned members.





Determination of Percent Water in a Hydrate

Unknown number	
Mass, crucible + lid + hydrate sample	
Mass, crucible + lid	
Mass, hydrate sample*	
Mass, crucible + lid + anhydrous product (1st heating)	
Mass, crucible + lid + anhydrous product (2nd heating)	
Mass, crucible + lid + product (3rd heating if necessary)	
Mass, water lost*	
Percent water in hydrate*	

Show the calculations for each of the entries in the Data Table marked with * on the calculations page.

1) Name the following hydrates:

$CoSO_4 \cdot 6\ H_2O$

$MgCl_2 \cdot 6\ H_2O$

$CuSO_4 \cdot 5\ H_2O$

2) Write formulas for the following hydrates:

Sodium dihydrogenphosphate nonahydrate

Potassium chromate tetrahydrate

Lead (II) acetate trihydrate

Report Form -- Hydrates 29

Hydrates Report

Include Replacement pg. 29

Have completed pg. 29 data & questions (both sides of handout including Post-Lab) in individual reports.

Hydrate: % Water

EPSOM SALT(s)

$MgSO_4 \bullet X\,H_2O(s)$

$X = ?$ [Possibilities: $X = 1, 4, 5, 6, 7$]

$$MgSO_4 \bullet X\,H_2O(s) \rightarrow MgSO_4(s) + X\,H_2O(g)$$

Mass sample — *Mass after heating* — *Mass sample - Mass after heating*

% H_2O = (*Mass sample - Mass after heating*) / *Mass sample* x 100

An "Epsom" salt sample (A) of 10.00 g was heated and re-heated until it reached a "constant" mass of 5.70 g. What is the % water in the sample?

An "Epsom" salt sample (B) of 10.00 g was heated and re-heated until it reached a "constant" mass of 4.88 g . What is the % water in the sample?

How can you identify (A) and (B) among the 5 choices?

http://chemconnections.org/general/chem108/Mole%20Guide.html

Moles & Mass

How big is a mole?
(Not the animal, the other one.) - Daniel Dulek

https://www.youtube.com/watch?v=TEl4jeETVmg

The Mole

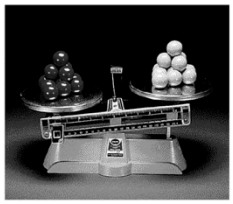
- Definition: The number of carbon atoms in exactly 12 grams of pure ^{12}C. The number equals **6.02×10^{23}** atoms.

✓ 1 mole = **6.02×10^{23} units of anything**

- **6.02×10^{23}** "units" of atoms, people, ants, stars, $$$s, etc., etc. = **1 mole**

There are about 7.4 billion people in the world. How many moles of people are there?

Counting by Weighing



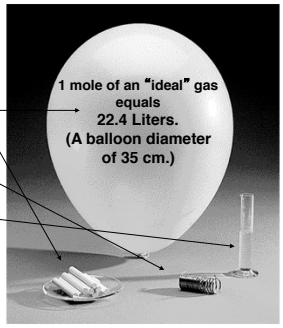
A
12 red marbles @ 7g each = 84g
12 yellow marbles @ 4g each=48g

B
55.85g Fe = 6.022 x 10^{23} atoms Fe
32.07g S = 6.022 x 10^{23} atoms S

Consult the Periodic Table

Relative Masses of 1 Mole

$CaCO_3$
Name?
100.09 g
Oxygen
32.00 g
Copper
63.55 g
Water
18.02 g



What is the volume of 1 mole of water?

Atomic and Molecular Weights

Mass Measurements

- **^{1}H weighs 1.6735 x 10^{-24} g and ^{16}O 2.6560 x 10^{-23} g.**
  - **DEFINITION: mass of ^{12}C = exactly 12 amu.**
  - **Using atomic mass units:**
- **1 amu = 1.66054 x 10^{-24} g**
- **1 g = 6.02214 x 10^{23} amu**

Atomic and Molecular Weights

- **Formula Weight a.k.a. Molecular Weight**
- **Formula weights (FW): sum of Atomic Weights (AW) for atoms in formula.**
- **FW (H_2SO_4) = 2AW(H) + AW(S) + 4AW(O)**
- **= 2(1.0 amu) + (32.0 amu) + 4(16.0)**
- **= 98.0 amu**

Atomic and Molecular Weights

- **Molecular weight (MW) is the weight of the molecular formula in amu.**
- **MW of sugar ($C_6H_{12}O_6$) = ?**
- **MW = 6(12.0 amu) + 12(1.0 amu) + 6(16.0 amu)**
- **= 180 amu**

Molar Mass

- A substance's **molar mass** is the mass in grams of one mole of the element or compound. (Equals the formula weight: atomic or molecular weight in grams)

Molar Mass CO_2 = ?

C = 12.01 grams per mole (g/mol)
O = 16.00 grams per mole (g/mol)

CO_2 = 44.01 grams per mole (g/mol)
12.01 + 2(16.00) = 44.01

Calculate the molar mass of magnesium sulfate.

What do you need ?

1) Formula of magnesium sulfate: $MgSO_4$

2) Atomic Weights (molar mass) Mg = 24.31, S = 32.07, O = 16.00

24.31 + 32.07 + 4(16.00) = **120.38** g/mo

Calculate the mass in grams of 4.00 moles of water.

What do you need ?

Atomic Weight H_2O (2H=1.0 x2) + (O=16.0)
(molar mass) = 18.0 g/mol

4 mol $_{sulfur}$ x 18.0 g/mol $_{sulfur}$ = **72.0** g

Calculate the mass in grams of 0.100 moles of magnesium sulfate hydrate.

What do you need ?

Atomic Weight $MgSO_4 \cdot H_2O$ = **120.38** + **18.02**
(molar mass) = 138.40 g/mol

0.100 mol $_{MgSO4.\ H2O}$ x 138.40 g/mol $_{MgSO4.\ H2O}$ = **13.84** g

Calculate the mass in grams of 0.100 moles of magnesium sulfate tetrahydrate.

What do you need ?

Atomic Weight $MgSO_4 \cdot 4H_2O$ = **120.38** + 4(**18.02**)
(molar mass) = 192.44 g/mol

0.100 mol $_{MgSO4.\ H2O}$ x 192.44 g/mol $_{MgSO4.\ H2O}$ = **19.244** g

Percent Composition

- Mass percent of an element:

$$\text{mass \%} = \frac{\text{mass of element in compound}}{\text{mass of compound}} \times 100\%$$

- For iron in iron (III) oxide = ? Fe_2O_3

$$\text{mass \% Fe} = \frac{111.69}{159.69} \times 100\% = 69.94\%$$

Which iron ore would you buy: one high in Fe_2O_3 or one high in Iron (II) oxide? FeO

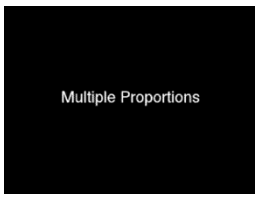
55.84 / 71.84 x 100 = 77.7%

Formulas: Dalton's Law

- Dalton's law of multiple proportions:

When two elements form different compounds, the mass ratio of the elements in one compound is related to the mass ratio in the other by a small whole number.

Formulas: Multiple Proportions



http://chemconnections.org/general/movies/multiple-proportions.MOV

Hydrate: % Water

EPSOM SALT(s)

$MgSO_4 \bullet X\,H_2O(s)$

X = ? [Possibilities: X = 1, 4, 5, 6, 7]

$MgSO_4 \bullet X\,H_2O(s) \rightarrow MgSO_4(s) + X\,H_2O(g)$

Mass sample — Mass after heating — Mass sample - Mass after heating

% H_2O = (*Mass sample - Mass after heating*) / *Mass sample* x 100

An "Epsom" salt sample (A) of 10.00 g was heated and re-heated until it reached a "constant" mass of 5.70 g. What is the % water in the sample?

An "Epsom" salt sample (B) of 10.00 g was heated and re-heated until it reached a "constant" mass of 4.88 g . What is the % water in the sample?

How can you identify (A) and (B) among the 5 choices?

Percent Composition

Calculate the percent water in magnesium sulfate pentahydrate.

What do you need ?

Atomic Weight $MgSO_4 \cdot 5\,H_2O$ = **120.38** + 5(**18.02**)
(molar mass) = 210.46 g/mol

Calculate the percent water in "Epsom" salt, magnesium sulfate heptahydrate

What do you need ?

Atomic Weight $MgSO_4 \cdot 7H_2O$ = **120.38** + 7(**18.02**)
(molar mass) = 246.49 g/mol

5(**18.02**)/ 210.46 x 100 =	7(**18.02**) / 246.49 x 100 =
42.8%	51.2%

Hydrate: % Water

EPSOM SALT(s)

$MgSO_4 \bullet X\,H_2O(s)$

X = ? [Possibilities: X = 1, 4, 5, 6, 7]

$MgSO_4 \bullet X\,H_2O(s) \rightarrow MgSO_4(s) + X\,H_2O(g)$

Mass sample — *Mass after heating* — *Mass sample - Mass after heating*

% H_2O = (*Mass sample - Mass after heating) / Mass sample x 100*

Hydrate	% H_2O
$MgSO_4 \bullet H_2O$	13.0
$MgSO_4 \bullet 4H_2O$	37.4
$MgSO_4 \bullet 5H_2O$	42.8
$MgSO_4 \bullet 6H_2O$	47.3
$MgSO_4 \bullet 7H_2O$	51.2

Formulas & Multiple Proportions

Components of acid rain, $SO_2(g)$ and $SO_3(g)$

- Compound A contains:
  1.000 g Sulfur & 1.500 g Oxygen
- Compound B contains:
  1.000 g Sulfur & 1.000 g Oxygen
- Mass ratio A: 1 to 1.5; Mass ratio B: 1 to 1
- MUST adjust for atomic mass differences: AW sulfur is 2x the AW oxygen; therefore the oxygen ratios are 2x sulfur.
- S_1O_3 and S_1O_2 respectively

EXPERIMENT

What's My Formula?

An experimental value is nearly impossible to have equal the calculated value due to inherent errors in conducting any experiment unlike the data provided for (A) and (B).

A quantitative comparison ("% Yield") is used to measure the efficiency (similar to "accuracy") of any procedure in yielding a "product" (on the right of an equation) versus the calculated (theoretical) amount of the product based on the reactant(s) (on the left of the equation) for any chemical reaction. In this experiment you will use a % comparison rather than % Yield which will come later.

$2\,NaHCO_3(s) \rightarrow Na_2CO_3(s) + H_2O(g) + CO_2(g)$

Unknown Sample — ***Salt***

EXPERIMENTAL:

% Salt = (*Mass sample - Mass after heating) / Mass sample x 100*

CALCULATIONS:

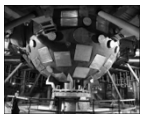
% Salt = *Molar Mass Salt /Molar Mass Unknown Sample x 100*

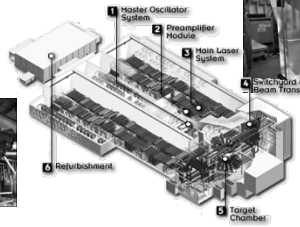
"Salt" / NIF / Fusion

What is "salt"?

sodium chloride

potassium dihydrogenphosphate





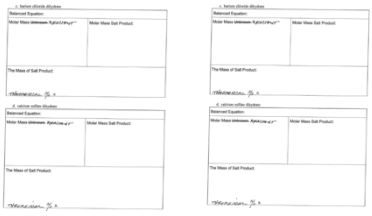
$^2H + {}^3H \rightarrow {}^4He + {}^1_0n + 18.38\,MeV$

5 grams of hydrogen will produce enough energy to boil over 1,000 gallons of water

Nomenclature Tutorial

http://www.chemconnections.org/general/chem108/Nomenclature.htm

- Pick one of the 4 "unknowns" (a, b, c, or d) so that each of you have a different unknown. (Modified pages 37 & 38)



Nomenclature

Move to the area designated for your unknown on the following Lab Map

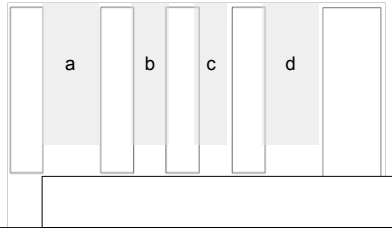
a = sodium hydrogen carbonate

b = potassium hydrogen carbonate

c = barium chloride dihydrate

d = calcium sulfate dihydrate

Front of Lab



Nomenclature / Naming

- Nomenclature: the unambiguous naming of compounds/ molecules
- Governed by the IUPAC: *International Union of Pure and Applied Chemistry*
- International rules are updated periodically

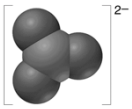
https://www.iupac.org/fileadmin/user_upload/databases/Red_Book_2005.pdf

Organic and Inorganic compounds/ molecules have separate naming rules.

Compounds with more than two different elements

- Polyatomic ions: [oxygen as the third atom]

http://chemconnections.org/general/chem120/polyatomics.html



Carbonate ion CO_3^{2-}

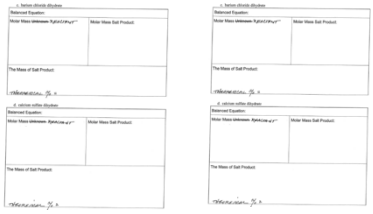
Common Polyatomic Ions

Ion	Name	Ion	Name
Hg_2^{2+}	Mercury(I)	NCS^-	Thiocyanate
NH_4^+	Ammonium	CO_3^{2-}	Carbonate
NO_2^-	Nitrite	HCO_3^-	Hydrogen carbonate (bicarbonate is a widely used common name)
NO_3^-	Nitrate		
SO_3^{2-}	Sulfite		
SO_4^{2-}	Sulfate	ClO^-	Hypochlorite
HSO_4^-	Hydrogen sulfate (bisulfate is a widely used common name)	ClO_2^-	Chlorite
		ClO_3^-	Chlorate
		ClO_4^-	Perchlorate
OH^-	Hydroxide	$C_2H_3O_2^-$	Acetate
CN^-	Cyanide	MnO_4^-	Permanganate
PO_4^{3-}	Phosphate	$Cr_2O_7^{2-}$	Dichromate
HPO_4^{2-}	Hydrogen phosphate	CrO_4^{2-}	Chromate
$H_2PO_4^-$	Dihydrogen phosphate	O_2^{2-}	Peroxide
		$C_2O_4^{2-}$	Oxalate

Nomenclature

http://www.chemconnections.org/general/chem108/Nomenclature.htm

- Determine the formula of the unknown; everyone must agree and then send a delegate to Dr. R, with your answer, who will supply the correct chemical equation when all groups have finished.



What's My Formula?

Unknowns

$BaCl_2 \cdot 2H_2O$

c. $BaCl_2 \bullet 2\,H_2O(s) \rightarrow BaCl_2\,(s) + 2\,H_2O(g)$

Unknown Sample — *Salt*

$CaSO_4 \cdot 2H_2O$

d. $CaSO_4 \bullet 2\,H_2O(s) \rightarrow CaSO_4\,(s) + 2\,H_2O(g)$

Unknown Sample — *Salt*

$NaHCO_3$

a. $2\,NaHCO_3(s) \rightarrow Na_2CO_3(s) + H_2O(g) + CO_2(g)$

Unknown Sample — *Salt*

$KHCO_3$

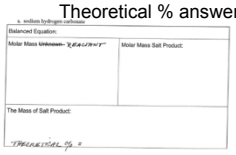
b. $2\,KHCO_3(s) \rightarrow K_2CO_3(s) + H_2O(g) + CO_2(g)$

Unknown Sample — *Salt*

Write the chemical reaction exactly as it is above for your respective unknown on each person's form.

What's My Formula?

Complete the calculations for your unknown, everyone must agree and then send a delegate to Dr. R, with your Theoretical % answer,.



$2\,NaHCO_3(s) \rightarrow 1Na_2CO_3(s) + H_2O(g) + CO_2(g)$

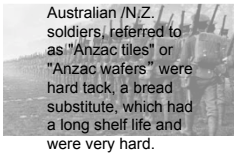
Unknown Sample — *Salt*

CALCULATIONS:

% Salt = [1x] ar Mass Salt / [2x] ar Mass *Unknown Sample* x 100

https://en.wikipedia.org/wiki/Anzac_biscuit

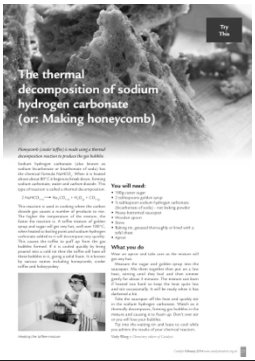
World War I (1914-1918)



Biscuits issued to Australian /N.Z. soldiers, referred to as "Anzac tiles" or "Anzac wafers" were hard tack, a bread substitute, which had a long shelf life and were very hard.

Mix golden syrup, boiling water and sodium bicarbonate until they froth. Add melted butter.

https://www.smh.com.au/national/nsw/anzac-day-2015-archive-wwi-letters-to-the-sydney-morning-herald-19151916-20150415-1mlctc.html



What's My Formula?

Correctly copy the formula, reaction and Theoretical % onto every form, check each others forms & then return to your original group

What's My Formula?

Unknowns

$BaCl_2 \cdot 2H_2O$

$BaCl_2 \cdot 2\ H_2O(s) \rightarrow BaCl_2\ (s) + 2\ H_2O(g)$

Unknown Sample ***Salt***

$CaSO_4 \cdot 2H_2O$

$CaSO_4 \cdot 2\ H_2O(s) \rightarrow CaSO_4\ (s) + 2\ H_2O(g)$

Unknown Sample ***Salt***

$NaHCO_3$

$2\ NaHCO_3(s) \rightarrow Na_2CO_3(s) + H_2O(g) + CO_2(g)$

Unknown Sample ***Salt***

$KHCO_3$

$2\ KHCO_3(s) \rightarrow K_2CO_3(s) + H_2O(g) + CO_2(g)$

Unknown Sample ***Salt***

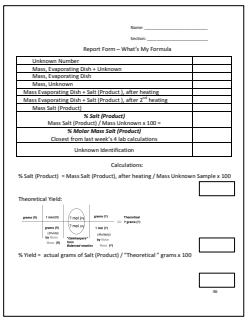
Experimental Calculation:

% Salt = (*Mass sample - Mass after heating) / Mass sample x 100*

Theoretical Calculation:

% Salt = ?*Molar Mass Salt / ?Molar Mass Unknown Sample x 100*

Your group is to obtain a minimum of 2 unknowns up to a maximum of 4 unknowns from Dr. R., then complete the procedure and an accompanying data form for each unknown that you choose (replaces pg. 36)



Name: _____

Section: _____

Report Form – What's My Formula

Unknown Number	
Mass, Evaporating Dish + Unknown	
Mass, Evaporating Dish	
Mass, Unknown	
Mass Evaporating Dish + Salt (Product), after heating	
Mass Evaporating Dish + Salt (Product), after 2nd heating	
Mass Salt (Product)	
% Salt (Product) Mass Salt (Product) / Mass Unknown x 100 =	
% Molar Mass Salt (Product) Closest from last week's X lab calculations	
Unknown Identification	

Calculations:

% Salt (Product) = Mass Salt (Product), after heating / Mass Unknown Sample x 100

Theoretical Yield:

% Yield = actual grams of Salt (Product) / "Theoretical " grams x 100

What's My Formula?

"% Yield" is used to measure the efficiency (similar to "accuracy") of any procedure in yielding "product(s)" (on the right of an equation) versus the calculated (theoretical) amount of the product based on the amount of "reactant(s)" (from the left of the equation) for any chemical reaction using the relative number of moles of each.

% Yield =

actual grams of product / theoretical (calculated) grams of product x100

For example, heating 10.00 g of sodium bicarbonate and actually obtaining *X* g of sodium carbonate

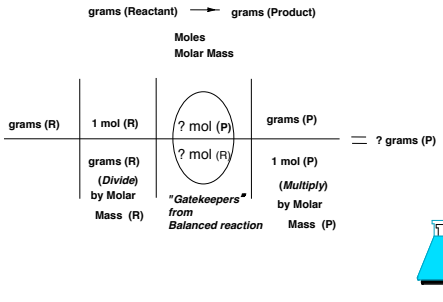
$2\ NaHCO_3(s) \rightarrow Na_2CO_3(s) + H_2O(g) + CO_2(g)$

$2\ mol\ NaHCO_3(s) : 1\ mol\ Na_2CO_3(s)$

Reactant = 10.00 g
Molar Mass = 84.00 g/ mol

Product = ? g (Theoretical)
Molar Mass = 105.99 g/ mol

Theoretical Mass (Yield) Calculations
Reactants ⟷ Products



What's My Formula?

Unknowns

$BaCl_2 \cdot 2H_2O$

$BaCl_2 \cdot 2\ H_2O(s) \rightarrow BaCl_2\ (s) + 2\ H_2O(g)$

Unknown Sample ***Salt***

$CaSO_4 \cdot 2H_2O$

$CaSO_4 \cdot 2\ H_2O(s) \rightarrow CaSO_4\ (s) + 2\ H_2O(g)$

Unknown Sample ***Salt***

$NaHCO_3$

$2\ NaHCO_3(s) \rightarrow Na_2CO_3(s) + H_2O(g) + CO_2(g)$

Unknown Sample ***Salt***

$KHCO_3$

$2\ KHCO_3(s) \rightarrow K_2CO_3(s) + H_2O(g) + CO_2(g)$

Unknown Sample ***Salt***

EXPERIMENTAL:

% Salt = (*Mass sample - Mass after heating) / Mass sample x 100*

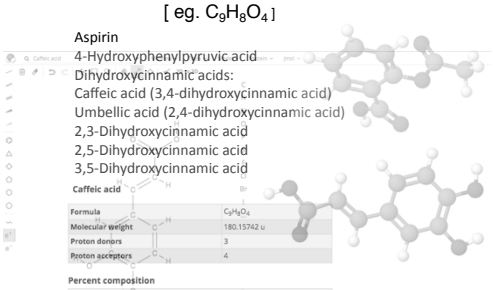
CALCULATIONS:

% Salt = ?*Molar Mass Salt / ?Molar Mass Unknown Sample x 100*

What's My Formula?

Post Lab: Compounds with the Same Formula
[eg. $C_9H_8O_4$]

Aspirin
4-Hydroxyphenylpyruvic acid
Dihydroxycinnamic acids:
Caffeic acid (3,4-dihydroxycinnamic acid)
Umbellic acid (2,4-dihydroxycinnamic acid)
2,3-Dihydroxycinnamic acid
2,5-Dihydroxycinnamic acid
3,5-Dihydroxycinnamic acid



Caffeic acid

Formula	$C_9H_8O_4$
Molecular weight	180.15742 u
Proton donors	3
Proton acceptors	4

Percent composition

C	12.0107 u × 9	60.001 %
H	1.00794 u × 8	4.4758 %
O	15.9994 u × 4	35.523 %

Post Lab: Compounds with the Same Formula
[eg. $C_9H_8O_4$]

Molar Comparisons of Analgesics

Calculate Moles : Doses (mmol/dose)

Which analgesic has the most biologically active ingredient based on millimoles per dose (*mmol/dose*)?

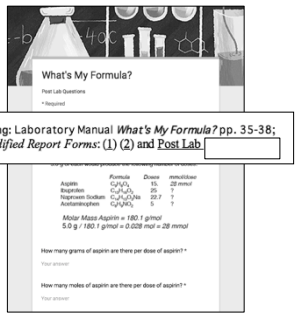
5.0 g of each would produce the following number of doses:

	Formula	*Doses*	*mmol/dose*
Aspirin	$C_9H_8O_4$	15.	*28 mmol*
Ibuprofen	$C_{13}H_{18}O_2$	25	?
Naproxen Sodium	$C_{14}H_{13}O_3Na$	22.7	?
Acetaminophen	$C_8H_9NO_2$	5	?

Molar Mass Aspirin = 180.1 g/mol
5.0 g */ 180.1 g/mol = 0.028 mol = 28 mmol*

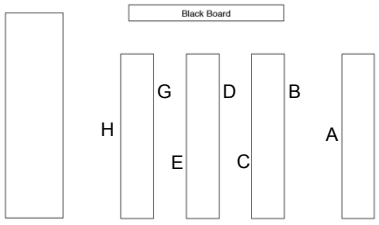
Post Lab:
Submit Individually

Molar Comparisons of Analgesics
Calculate Moles : Doses (mmol/dose)



Chem 108: Lab
Week 7

Sign in
Pick up papers
Sit with group partners from last week's lab



Name: _____

Section: _____

Report Form – What's My Formula

Unknown Number	
Mass, Evaporating Dish + Unknown	
Mass, Evaporating Dish	
Mass, Unknown	
Mass Evaporating Dish + Salt (Product), after heating	
Mass Evaporating Dish + Salt (Product), after 2nd heating	
Mass Salt (Product)	
% Salt (Product)	
Mass Salt (Product) / Mass Unknown x 100 =	
% Molar Mass Salt (Product)	
Closest from last week's 4 lab calculations	
Unknown Identification	

Calculations:

% Salt (Product) = Mass Salt (Product), after heating / Mass Unknown Sample x 100

Theoretical Yield:

% Yield = actual grams of Salt (Product) / "Theoretical " grams x 100

QUESTION

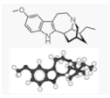
- A synthetic reaction produced 2.45g of Ibogaine, $C_{20}H_{26}N_2O$, a natural product with strong promise in treating heroin addiction, the calculated theoretical yield was 3.05g, what is the % yield?

A) 19.7% B) 39.4% C) 80.3% D) 160.6%

$C_{20}H_{26}N_2O$

(Ibogaine)

Tabernanthe iboga



ANSWER

- If a reaction produced 2.45g of Ibogaine, $C_{20}H_{26}N_2O$, a natural product with strong promise in treating heroin addiction, and the theoretical yield was 3.05g, what is the % yield?

A) 19.7% B) 39.4% C) 80.3% D) 160.6%

% yield = 2.45g / 3.05g x 100

= 80.3%