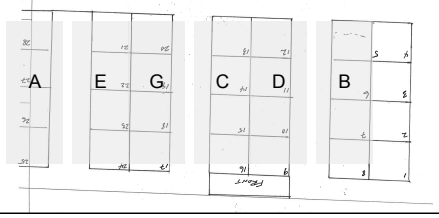
Chem 108: Lab

Week 6

Sign in: Note the letter next to your name

Sit in the Area Noted with that letter on the following Lab Map



Experiment 4: Hydrates

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

DUE Today

Name: _____

Section: _____

Report Form – Hydrates

Describe the odor and appearance of the liquid collected by heating the copper (II) sulfate.

Report your observations when your liquid and deionized water are tested with cobalt chloride paper and when your liquid and deionized water are reacted with the white residue.

Include if you did this part of the experiment

What do your observations tell you about the nature of the liquid collected by heating the hydrated copper (II) sulfate? Why?

Answer this part based on your observations in the Classification of Matter experiment or the above.

Include Data (pg. 29)

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.

Post-Lab Question:

Spectroscopic satellite analysis of the composition of the moon was completed during the Clementine and subsequent NASA missions. The data indicates that water is present on the moon and there may be enough to allow human colonization. The water is tied up in rock (hydrates) and as ice. A notable hydrate for its high water content is Glauber's salt, sodium sulfate decahydrate. If a human were to require the equivalent of 2 liters of water per day, how many kilograms of Glauber's salt would need to be processed per month to meet one person's need. Assume a month is 30 days and that all of the water in the salt is recovered in the process. Glauber's Salt is 56% water by weight.

Hydrate: % Water

EPSOM SALT

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

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

$$\underset{\text{Mass sample}}{MgSO_4 \bullet X\,H_2O(s)} \rightarrow \underset{\text{Mass after heating}}{MgSO_4(s)} + \underset{\text{Mass sample - Mass after heating}}{X\,H_2O(g)}$$

% 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

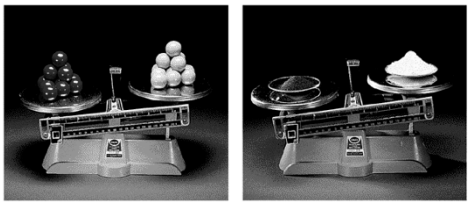
https://www.youtube.com/watch?v=TEl4jeETVmg

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



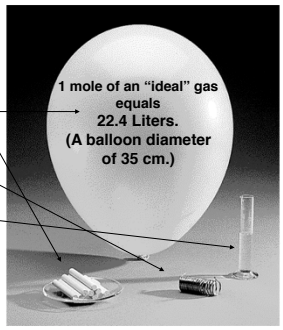
A
12 red marbles @ 7g each = 84g
12 yellow marbles @ 4g each=48g

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

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%

Hydrate: % Water
EPSOM SALT

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

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

$$\underset{\text{Mass sample}}{MgSO_4 \bullet X\,H_2O(s)} \rightarrow \underset{\text{Mass after heating}}{MgSO_4(s)} + \underset{\text{Mass sample - Mass after heating}}{X\,H_2O(g)}$$

% 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

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

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

$$\underset{\text{Mass sample}}{MgSO_4 \bullet X\,H_2O(s)} \rightarrow \underset{\text{Mass after heating}}{MgSO_4(s)} + \underset{\text{Mass sample - Mass after heating}}{X\,H_2O(g)}$$

% 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

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.

$$\underset{\text{Unknown Sample}}{2\,NaHCO_3(s)} \rightarrow \underset{\text{Salt}}{Na_2CO_3(s)} + H_2O(g) + CO_2(g)$$

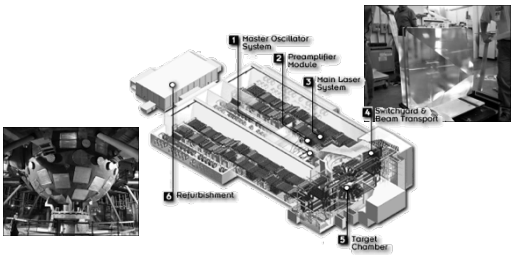
EXPERIMENTAL:

% 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"?



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

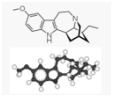
5 grams of hydrogen will produce enough energy to boil over 1,000 gallons of water

Chemical Formulas ⟷ Unambiguous Names

- Molecular Formula:
- **Elements' Symbols** = atoms
- **Subscripts** = relative numbers of atoms
- How are compounds named?

$CaCl_2$ CCl_4 NaOH $(NH_4)_2CO_3$

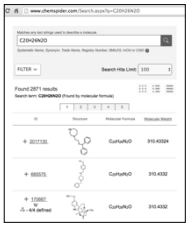
$C_{20}H_{26}N_2O$
(Ibogaine)
Tabernanthe iboga



Chemical Formulas and Unambiguous Names

- Molecular Formula:

$C_{20}H_{26}N_2O$



Search term: $C_{20}H_{26}N_2O$ produced 2871 results, ***where names were all different.***

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

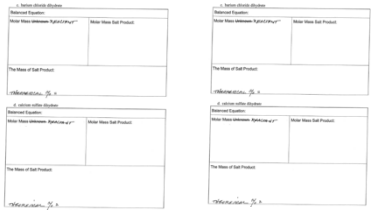
https://www.iupac.org/fileadmin/user_upload/databases/Red_Book_2005.pdf

Organic and Inorganic compounds/ molecules have separate naming rules.

Nomenclature Tutorial

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

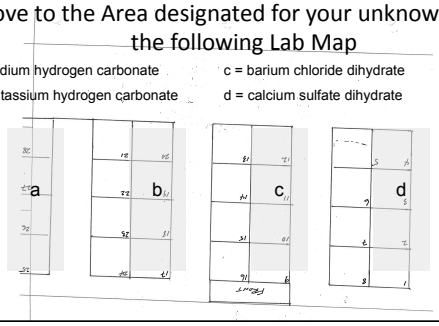
- Pick one of the 4 "unknowns" (a, b, c, or d) so that each of you have a different unknown (2 of you can double on one if there are more than 4 in your group.)



Move Locations Once More

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

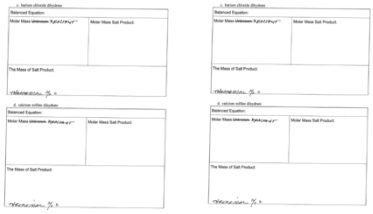
a = sodium hydrogen carbonate
b = potassium hydrogen carbonate
c = barium chloride dihydrate
d = calcium sulfate dihydrate



Nomenclature Tutorial

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

$BaCl_2 \cdot 2H_2O$

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

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***

$KHCO_3$

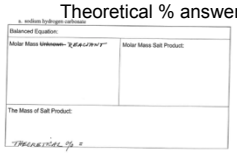
$2\,KHCO_3(s) \rightarrow K_2CO_3(s) + H_2O(g) + CO_2(g)$

Unknown Sample ***Salt***

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,.



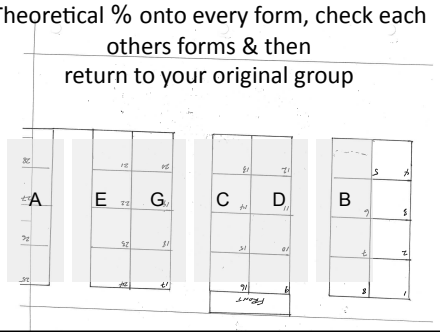
$$2\ NaHCO_3(s) \rightarrow 1Na_2CO_3(s) + H_2O(g) + CO_2(g)$$

Unknown Sample — Salt

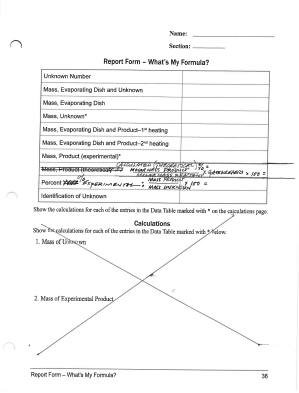
CALCULATIONS:

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

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



Your group is to obtain a minimum of 1 unknown or up to a maximum of 4 unknowns from Dr. R. then complete the procedure and the accompanying data form for each unknown that you choose. Put everyone's name in your group on each form.


Name: _____
Section: _____

Report Form – What's My Formula?

Unknown Number	
Mass, Evaporating Dish and Unknown	
Mass, Evaporating Dish	
Mass, Unknown*	
Mass, Evaporating Dish and Product–1st heating	
Mass, Evaporating Dish and Product–2nd heating	
Mass, Product (experimental)*	
Percent Yield*	
Identification of Unknown	

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

Calculations

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

1. Mass of Unknown

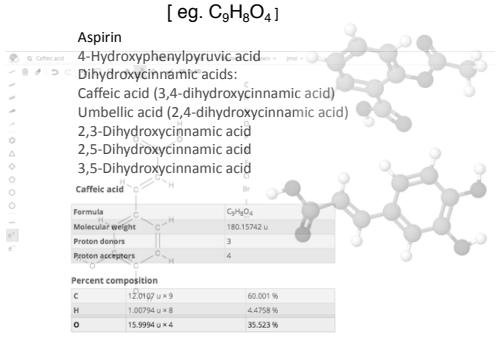
2. Mass of Experimental Product

Report Form – What's My Formula? 36

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



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*