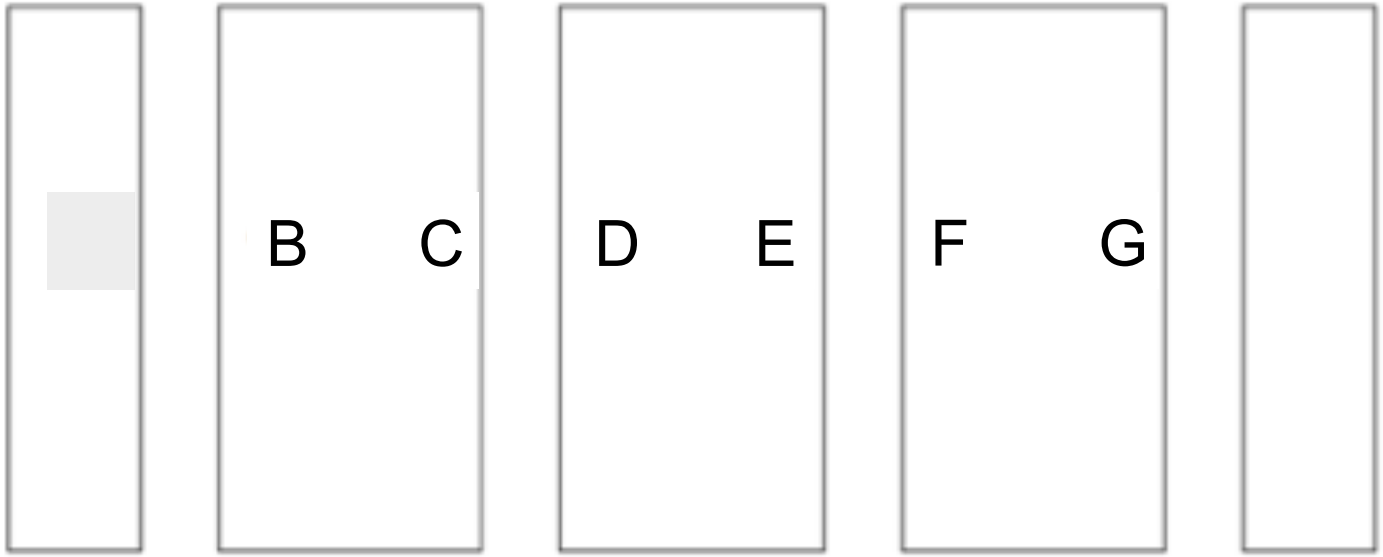
Chem 108: Lab

Week 7
Experiment:

What's My Formula?

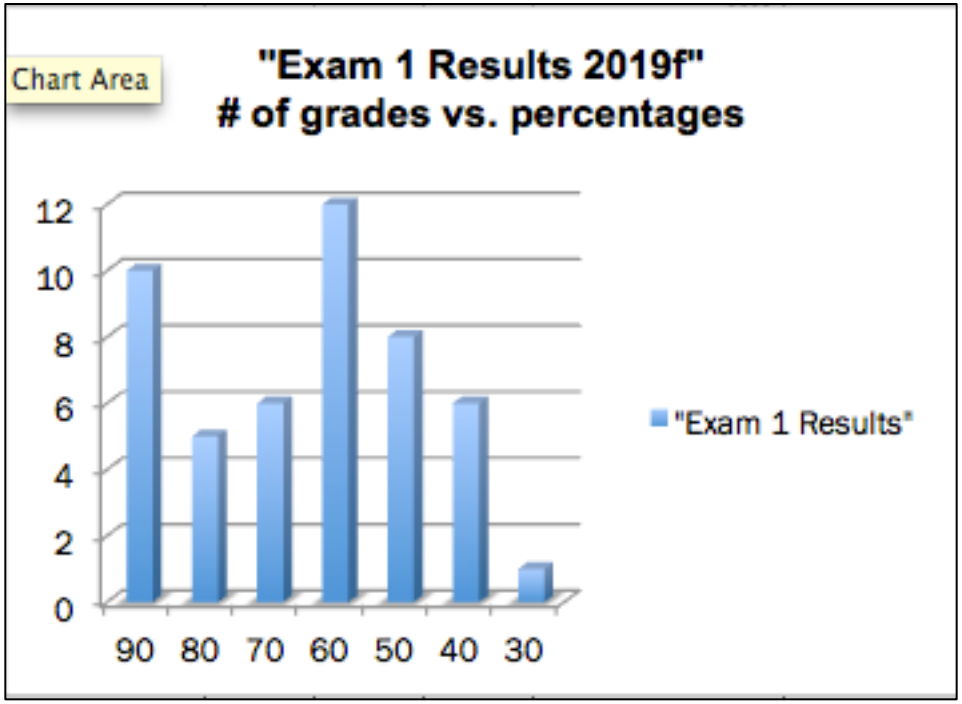
Sign in; PICK UP papers,
Check Group # on the roster, and go to that Group's lab location below.

Front of Lab



Introduce yourself to your Group members.

Divide raw score by 115 and multiply by 100 for Normalized %.



WEDS. lab- Pick up Exam 1 from the Pendaflex file

Class Average = 70.0 % (Normalized)
StdDev = +/-18

Pick up Notes & P.T. if you turned them in.

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.

DUE End of Next Lab

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*	

Hydrates Report

include the 2 Replacement pgs.: pp. 29 with the Report

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

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?

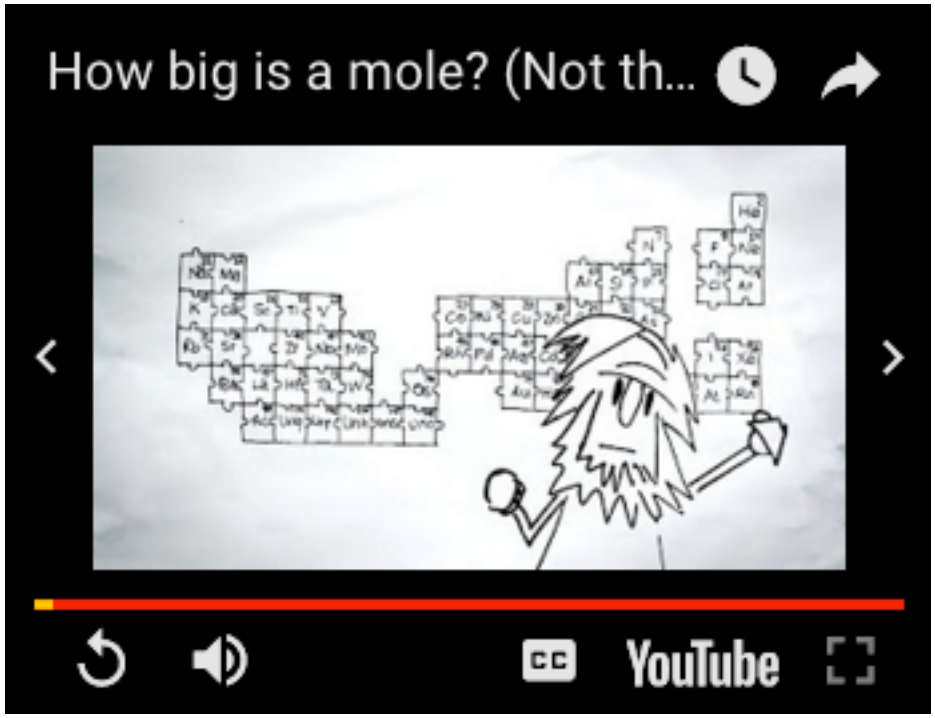
An "Epsom" salt sample (B) of 10.00 g was heated and re-heated until it reached a "constant" mass of 4.88 g . What is the % water in the sample?

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 7.7 billion people in the world.
(~300,000 being added every day.)
How many moles of people are there?

https://www.worldometers.info/world-population/

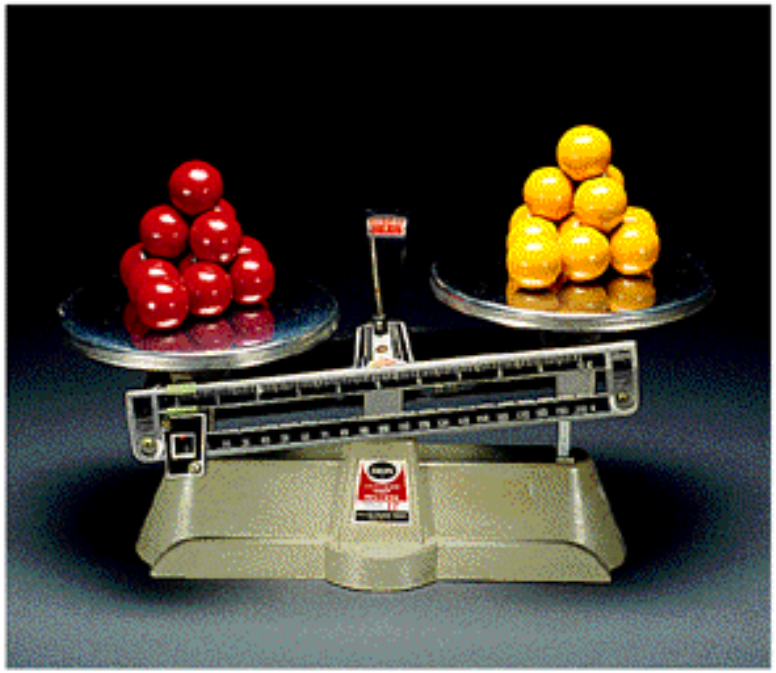
The Mole

There are about 7.7 billion people in the world.
(+300 million since the spring.)
How many moles of people are there?

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

$$\frac{7.7 \times 10^{9} \text{ people}}{6.02 \times 10^{23} \text{ people}} \times \frac{1 \text{ mol}}{} = 1.3 \times 10^{-14} \text{ mol}$$

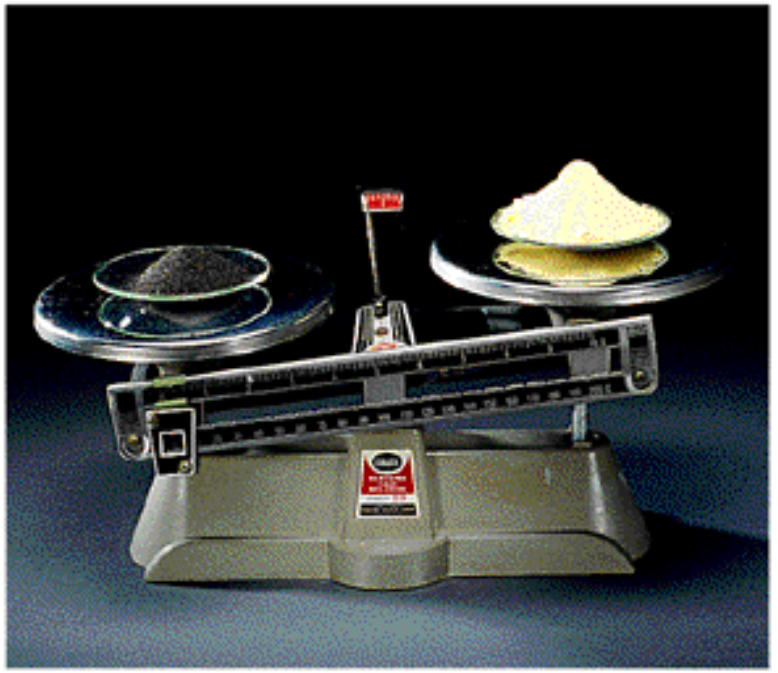
Counting by Weighing



A

12 red marbles @ 7g each = 84g

12 yellow marbles @ 4g each=48g



B

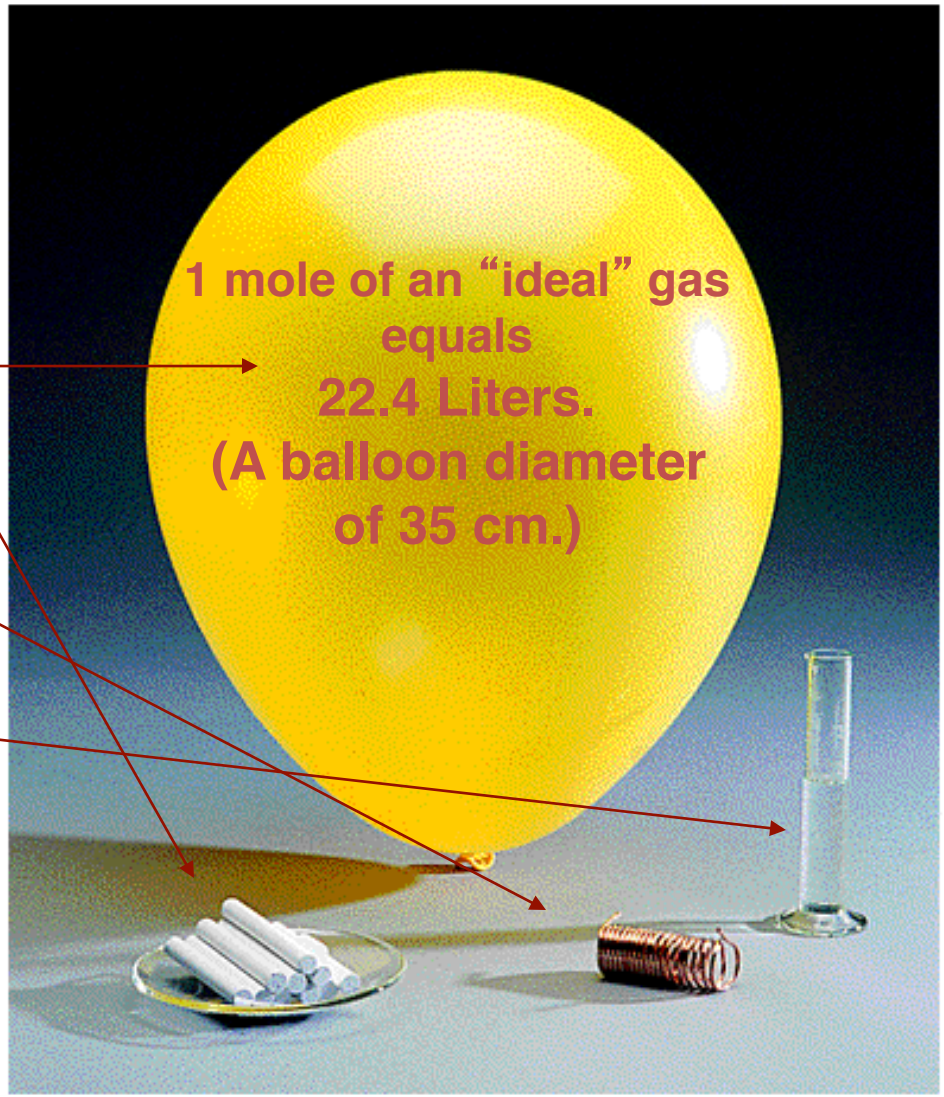
55.85g Fe = 6.022×10^{23} atoms Fe

32.07g S = 6.022×10^{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

- **DEFINITION: mass of ^{12}C = exactly 12 amu.**
- **Using atomic mass units:**

- **$1\ amu = 1.66054 \times 10^{-24}\ g$**
- **$1\ g = 6.02214 \times 10^{23}\ amu$**

Atomic and Molecular Weights

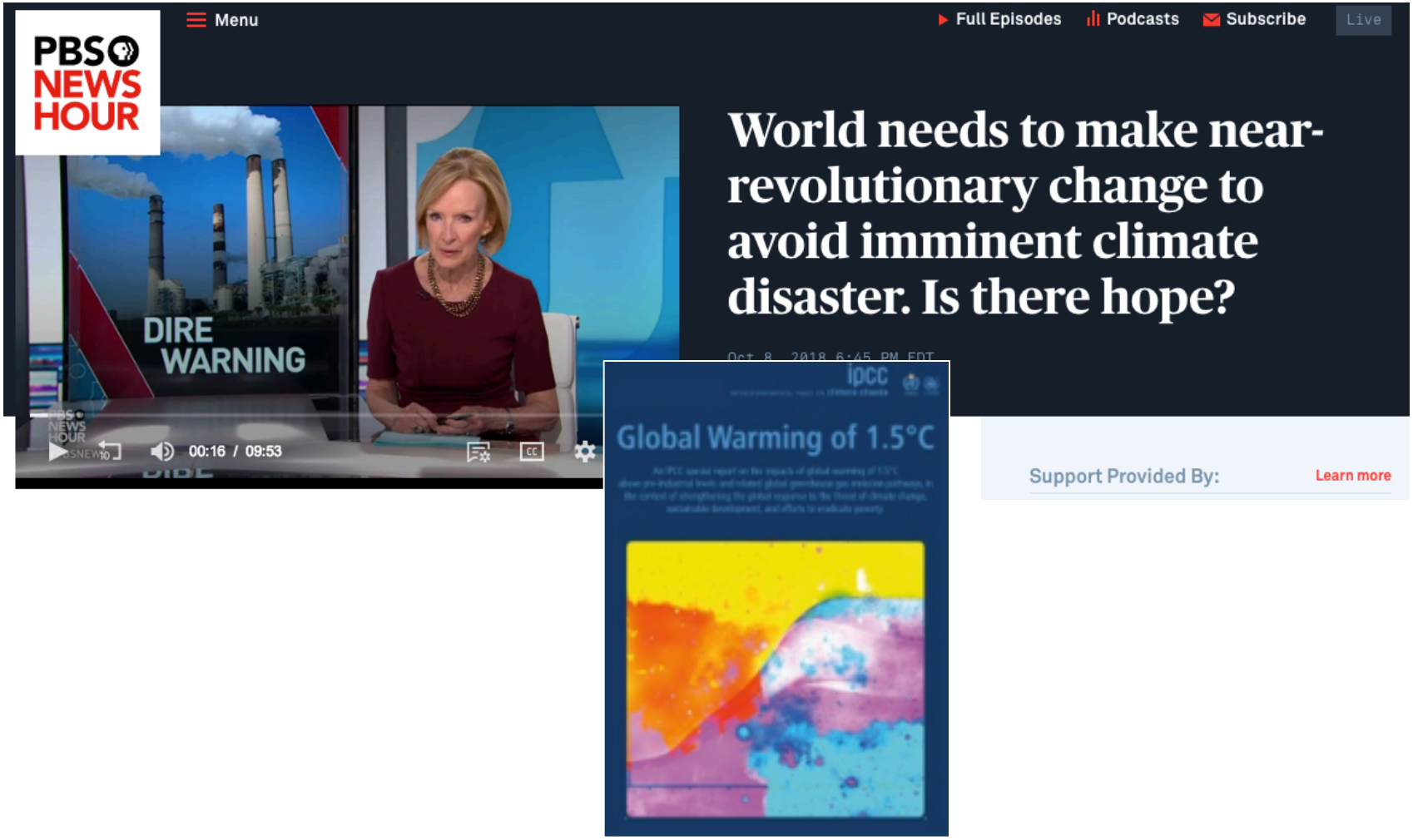
Mass Measurements

https://www.youtube.com/watch?v=ypbb9Zi5Tao&list=PLE7B4FAD08F1EBCE2

— DE **actly 12**

Recent Unite inues to describe ecc s, increased wildfires, hurricanes, typhoons, accelerated extinctions, and a mass die-off of coral reefs as soon as 2040 due to an increase in temperature by as much as 2.7 degrees Fahrenheit (1.5 degrees Celsius)

http://www.ipcc.ch/report/sr15/



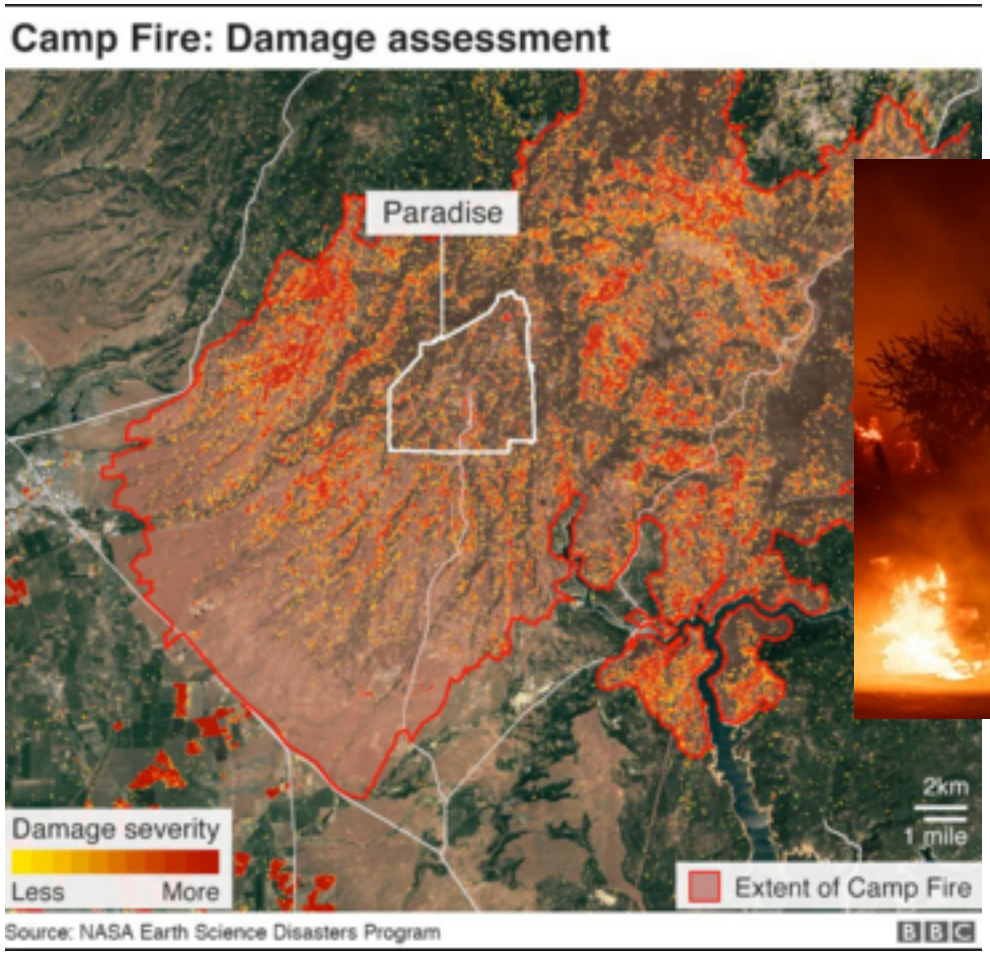
https://www.pbs.org/newshour/show/world-needs-to-make-near-revolutionary-change-to-avoid-imminent-climate-disaster-is-there-hope

Hurricane Michael
2018

Hurricane Maria
2017

https://www.pbs.org/newshour/show/world-needs-to-make-near-revolutionary-change-to-avoid-imminent-climate-disaster-is-there-hope

FEMA has provided at least $81 billion to state, territorial and local governments in response to declared disasters since 1992: to rebuild in place, often in defiance of the effects of climate change.

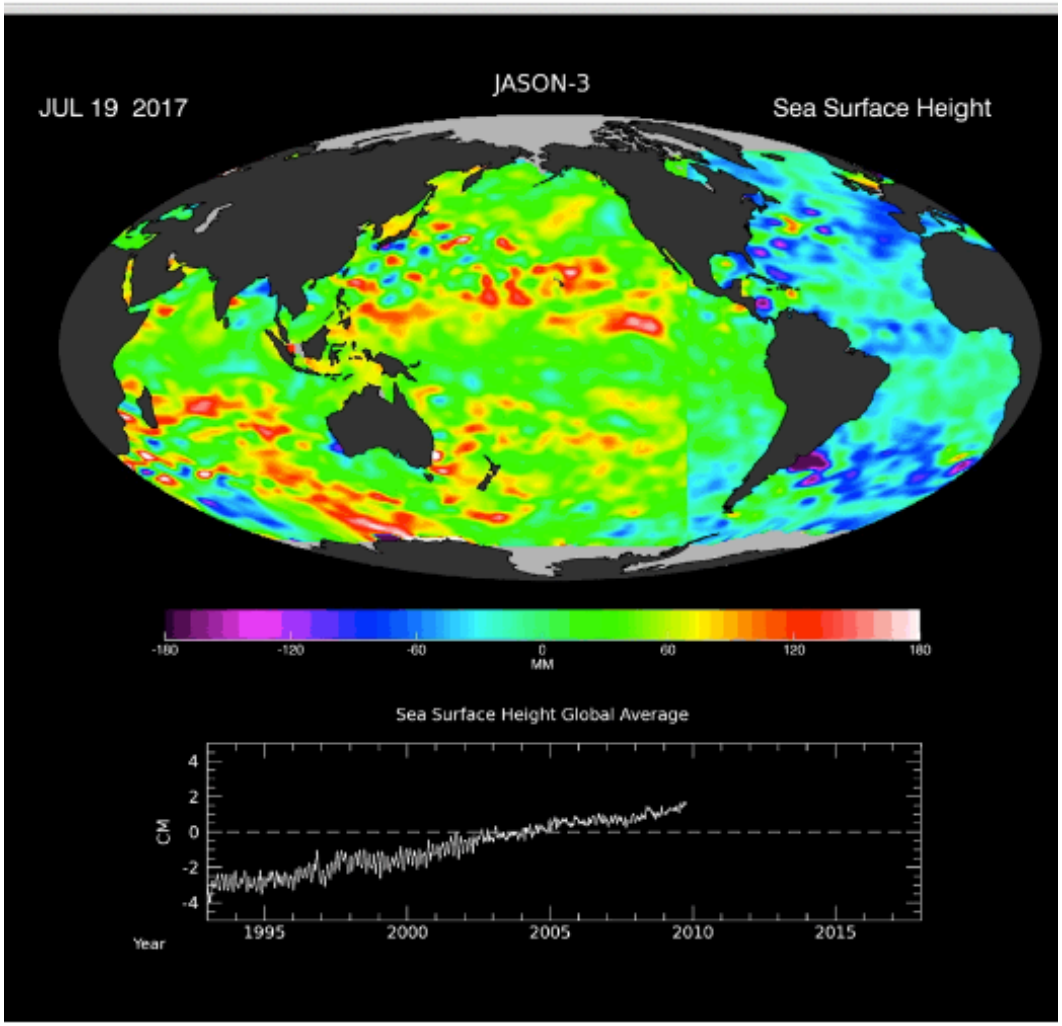


Camp Fire CA

November 2018

https://www.pbs.org/newshour/show/world-needs-to-make-near-revolutionary-change-to-avoid-imminent-climate-disaster-is-there-hope

25 Years of Global Sea Level Data



https://www.jpl.nasa.gov/images/topex/20170810/topex-jason20170810-16.gif

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

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

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 amu)**
- **= 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

(**amu/mol = grams/mol**)

- 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 g/mol

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

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

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 $_{MgSO4 \cdot H2O}$ x 138.40 g/mol $_{MgSO4 \cdot H2O}$ = **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

$$0.100 \text{ mol}_{MgSO4.\ H2O} \times 192.44 \text{ g/mol}_{MgSO4.\ H2O} = \mathbf{19.244}\ \text{g}$$

Percent Composition

- Mass percent of an element:

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

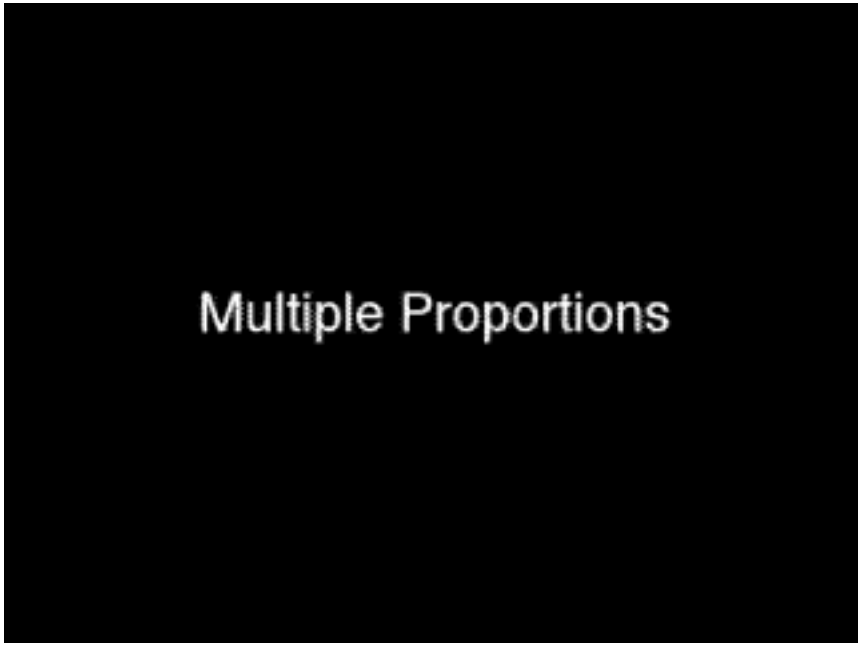
- For iron in iron (III) oxide = ? Fe_2O_3

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

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: 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*

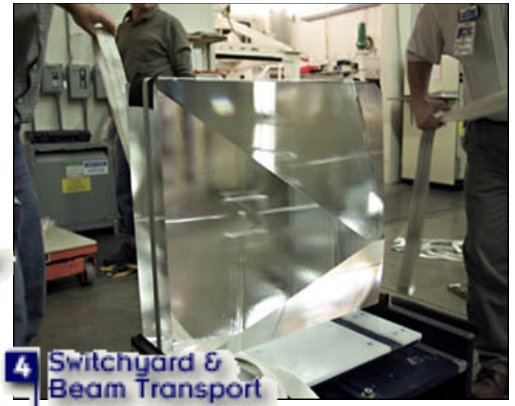
	Hydrate	% H_2O	% $MgSO_4$
	$MgSO_4 \bullet H_2O$	13.0	87.0
	$MgSO_4 \bullet 4H_2O$	37.4	62.6
A	$MgSO_4 \bullet 5H_2O$	42.8	57.2
	$MgSO_4 \bullet 6H_2O$	47.3	52.7
B	$MgSO_4 \bullet 7H_2O$	51.2	48.8

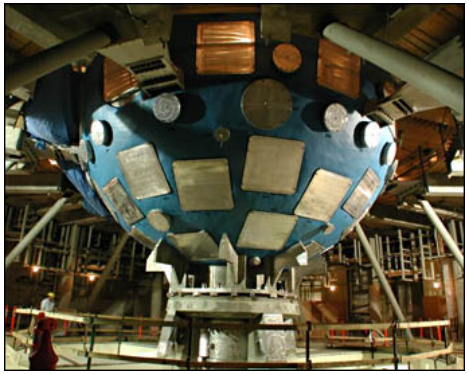
“Salt” / NIF / Fusion

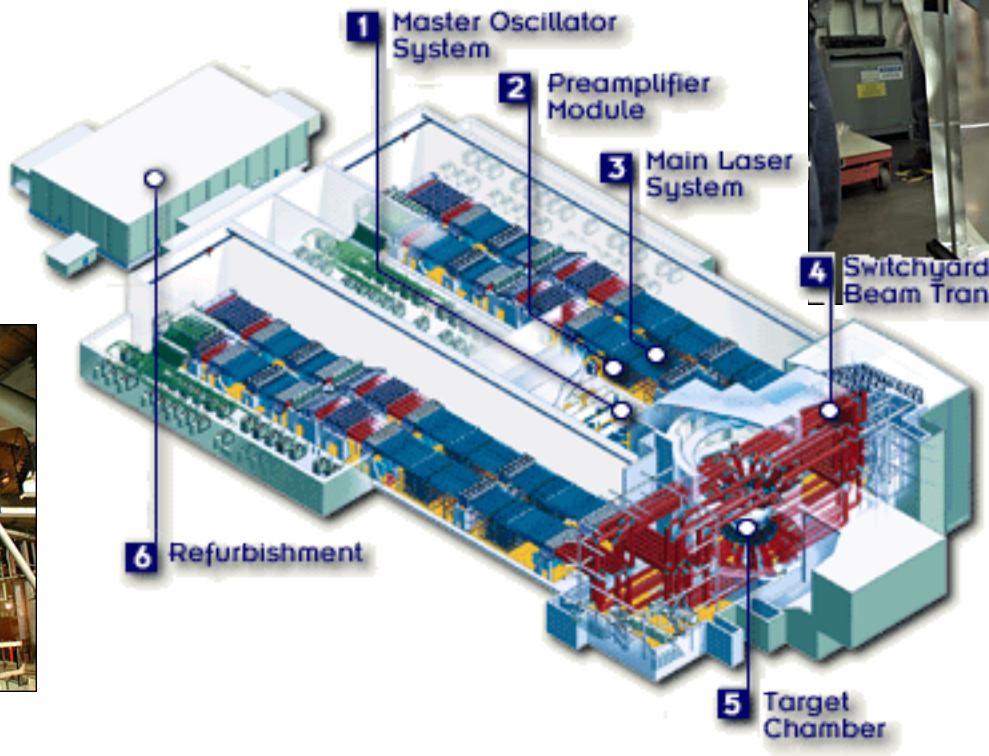
What is “salt”?

sodium chloride

potassium dihydrogenphosphate







$$^{2}H + ^{3}H \rightarrow ^{4}He + ^{1}_{0}n + 18.38MeV$$

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

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.

Today's Experiment

What's My Formula?

Nomenclature & Formulas

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

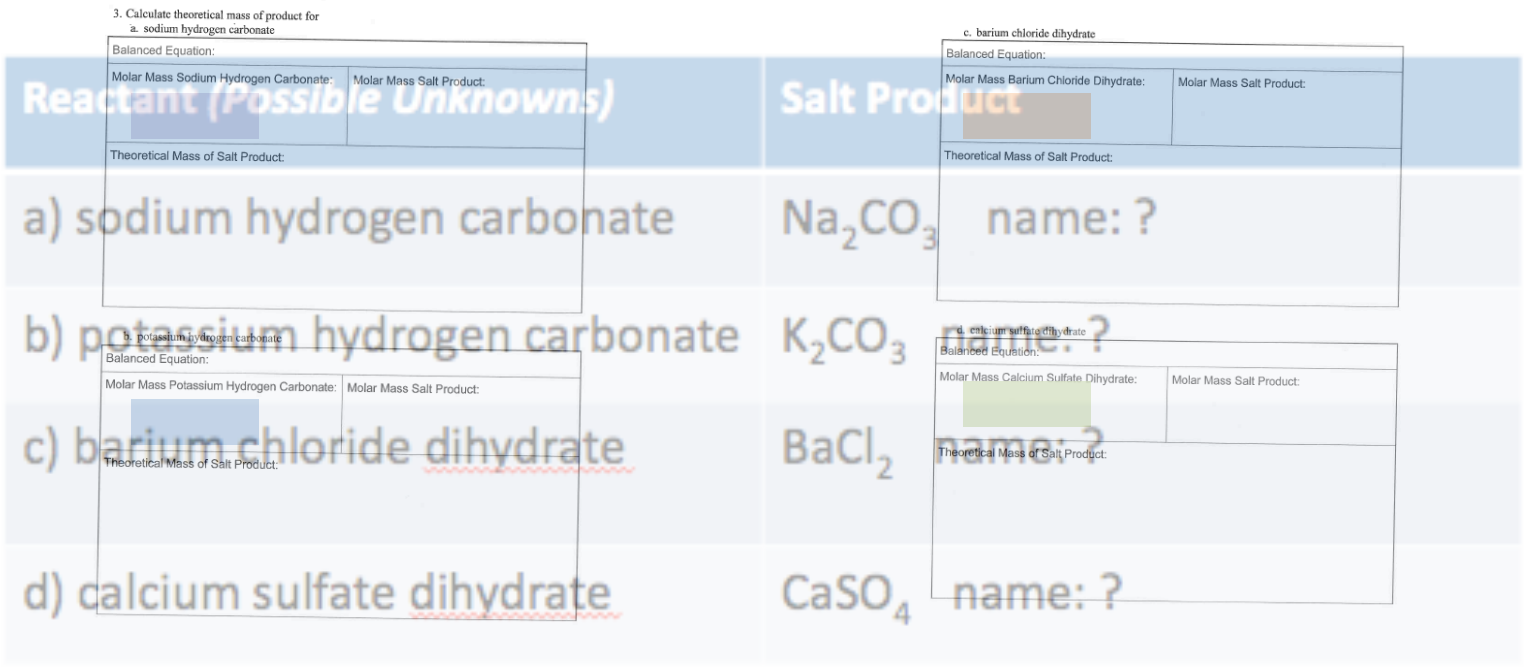
Reactant *(Possible Unknowns)*	**Salt Product**
a) sodium hydrogen carbonate	Na_2CO_3 name: ?
b) potassium hydrogen carbonate	K_2CO_3 name: ?
c) barium chloride dihydrate	$BaCl_2$ name: ?
d) calcium sulfate dihydrate	$CaSO_4$ name: ?

On each Report Form write the formulas for each Reactant and the name of the corresponding Product as shown on next slide

Nomenclature & Formulas

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

Write the formulas in the boxes on your form noted below, and the names of the Products in the respective boxes next to them. Review everyone's formulas and names for correctness.



Compounds with more than two different elements

- Polyatomic ions:
  http://chemconnections.org/general/chem120/polyatomics.html

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

Today's Experiment

What's My Formula?

Nomenclature & Formulas

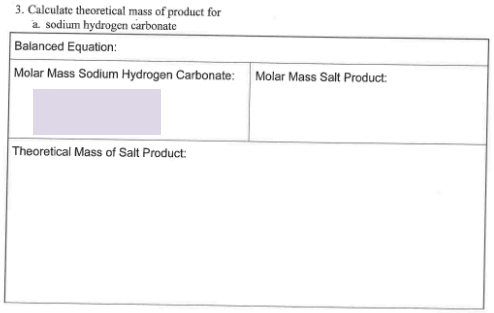
http://www.chemconnections.org/general/chem108/Nomenclature.htm

Reactant *(Possible Unknowns)*	Salt Product
a) sodium hydrogen carbonate $NaHCO_3$	Na_2CO_3 name: ? sodium carbonate
b) potassium hydrogen carbonate $KHCO_3$	K_2CO_3 name: ? potassium carbonate
c) barium chloride dihydrate $BaCl_2 \cdot 2H_2O$	$BaCl_2$ name: ? barium chloride
d) calcium sulfate dihydrate $CaSO_4 \cdot 2H_2O$	$CaSO_4$ name: ? calcium sulfate

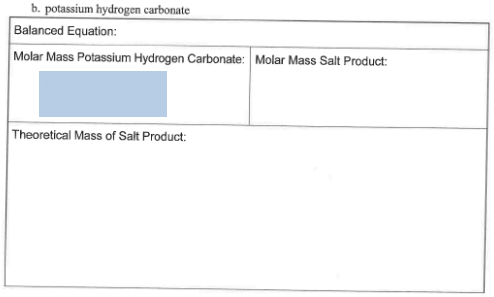
Nomenclature & Formulas

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

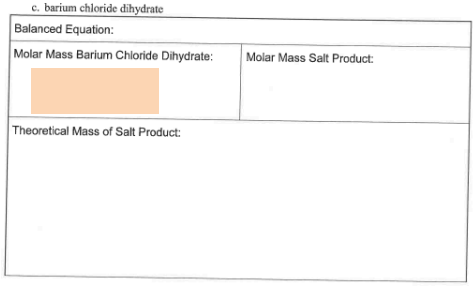
- Each of you choose 1 of the possible unknowns a., b., c., or d.
  Be sure the choices are all different.


3. Calculate theoretical mass of product for
a. sodium hydrogen carbonate

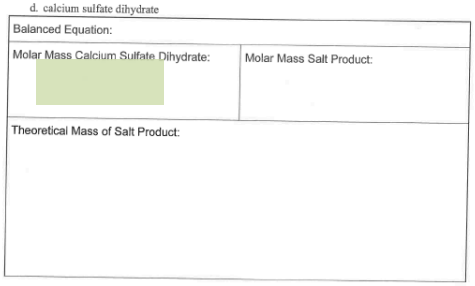
Balanced Equation:	
Molar Mass Sodium Hydrogen Carbonate:	Molar Mass Salt Product:
Theoretical Mass of Salt Product:	


b. potassium hydrogen carbonate

Balanced Equation:	
Molar Mass Potassium Hydrogen Carbonate:	Molar Mass Salt Product:
Theoretical Mass of Salt Product:	


c. barium chloride dihydrate

Balanced Equation:	
Molar Mass Barium Chloride Dihydrate:	Molar Mass Salt Product:
Theoretical Mass of Salt Product:	


d. calcium sulfate dihydrate

Balanced Equation:	
Molar Mass Calcium Sulfate Dihydrate:	Molar Mass Salt Product:
Theoretical Mass of Salt Product:	

What's My Formula?

Unknowns

a. $NaHCO_3$

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

Unknown Sample — Salt

b. $KHCO_3$

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

Unknown Sample — Salt

c. $BaCl_2 \cdot 2H_2O$

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

Unknown Sample — Salt

d. $CaSO_4 \cdot 2H_2O$

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

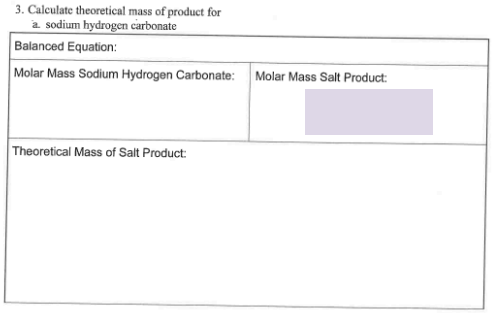
Unknown Sample — Salt

Write the equation for your chemical reaction ***exactly*** as it is written above for your unknown on your form in the ***Balanced Equation*** box.

Nomenclature & Formulas

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

- Select the formula for the salt product that is produced from heating your unknown and clearly show a labeled calculation of the respective molar masses of the Reactant and the Product. **Record the molar masses of all eight compounds on each individual form: 4 starting reactants and 4 salt products.**

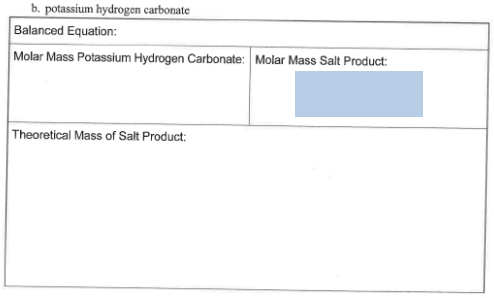

3. Calculate theoretical mass of product for
a. sodium hydrogen carbonate

Balanced Equation:

Molar Mass Sodium Hydrogen Carbonate:

Molar Mass Salt Product:

Theoretical Mass of Salt Product:

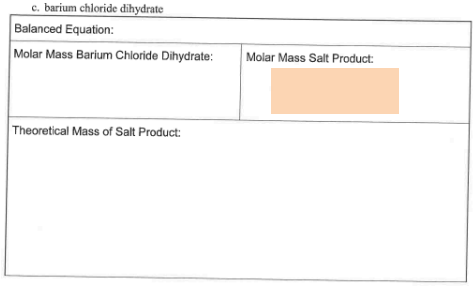

b. potassium hydrogen carbonate

Balanced Equation:

Molar Mass Potassium Hydrogen Carbonate:

Molar Mass Salt Product:

Theoretical Mass of Salt Product:

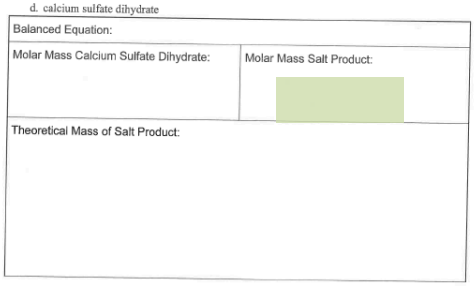

c. barium chloride dihydrate

Balanced Equation:

Molar Mass Barium Chloride Dihydrate:

Molar Mass Salt Product:

Theoretical Mass of Salt Product:


d. calcium sulfate dihydrate

Balanced Equation:

Molar Mass Calcium Sulfate Dihydrate:

Molar Mass Salt Product:

Theoretical Mass of Salt Product:

What's My Formula?

Unknowns

$BaCl_2 \cdot 2H_2O$

$1\ BaCl_2 \cdot 2\ H_2O(s) \rightarrow 1 BaCl_2\ (s) + 2\ H_2O(g)$

Unknown Sample — Salt

$CaSO_4 \cdot 2H_2O$

$1\ CaSO_4 \cdot 2\ H_2O(s) \rightarrow 1\ CaSO_4\ (s) + 2\ H_2O(g)$

Unknown Sample — Salt

$NaHCO_3$?

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

Unknown Sample — Salt

$KHCO_3$

$2\ KHCO_3(s) \rightarrow 1 K_2CO_3(s) + H_2O(g) + CO_2(g)$

Unknown Sample — Salt

Theoretical Calculations for Hydrates:

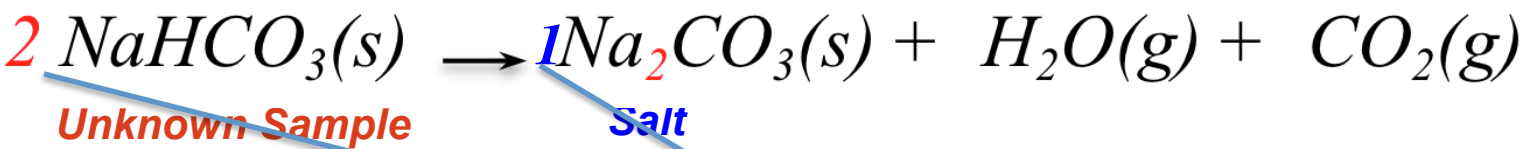
1 mole hydrate = 1 mole Salt Product (Unknowns c. and d.)

Theoretical Mass of Salt Product = Molar Mass of Salt Product

Unknowns a. and b. 1 mole hydrogen carbonate = ½ mole Salt Product

What's My Formula?

As a Group, calculate the Mass Percent Composition of the salt products relative to the respective starting unknown in each of the 4 possible unknowns: their respective Theoretical Mass equals the Molar Mass. Note that sodium hydrogen carbonate and potassium hydrogen carbonate have to include an adjustment for the difference in the number of moles produced relative to the starting reactant. Example:



Theoretical Calculations for hydrogen carbonates:

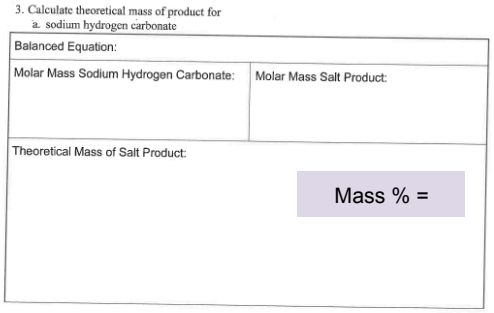
$$Mass\ Salt = Molar\ Mass\ Salt\ (g/mol)\ x\ 1\ mol_{salt}\ /\ 2\ mol_{HCO3-}$$

1 mole hydrogen carbonate = ½ mole Salt Product

$$Mass\ \%\ Salt = Theoretical\ Mass\ Salt\ /\ Molar\ Mass_{unknown}\ x\ 100$$

Theoretical Mass & Mass % Salt Product

- Show clear calculations for the Mass % of the respective Salt Products for each of the 4 unknowns a., b., c., & d. Circle or highlight the Mass % for the unknowns on your form as shown below.

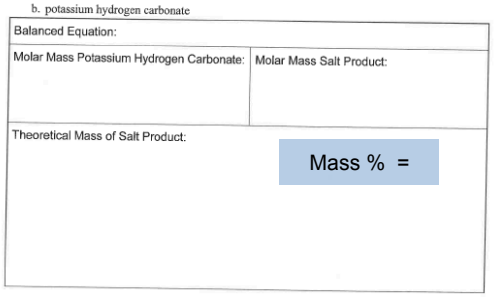

3. Calculate theoretical mass of product for
a. sodium hydrogen carbonate

Balanced Equation:

Molar Mass Sodium Hydrogen Carbonate: | Molar Mass Salt Product:

Theoretical Mass of Salt Product:

Mass % =

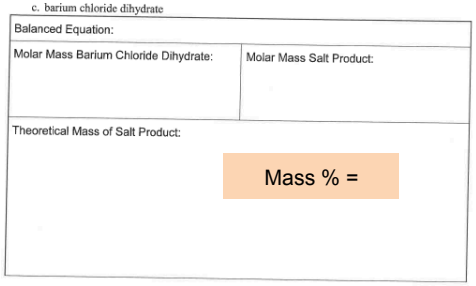

b. potassium hydrogen carbonate

Balanced Equation:

Molar Mass Potassium Hydrogen Carbonate: | Molar Mass Salt Product:

Theoretical Mass of Salt Product:

Mass % =

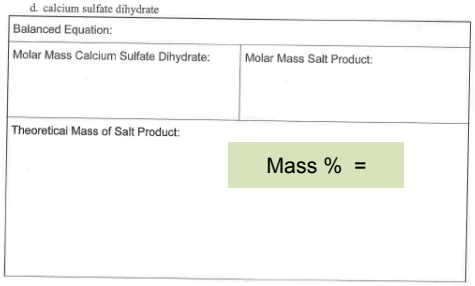

c. barium chloride dihydrate

Balanced Equation:

Molar Mass Barium Chloride Dihydrate: | Molar Mass Salt Product:

Theoretical Mass of Salt Product:

Mass % =


d. calcium sulfate dihydrate

Balanced Equation:

Molar Mass Calcium Sulfate Dihydrate: | Molar Mass Salt Product:

Theoretical Mass of Salt Product:

Mass % =

What's My Formula?

Your group is to obtain a minimum of 2 unknowns up to a maximum of 4 or 5 unknowns from Dr. R., then complete the procedure. Each of you will complete a data form for one unknown (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 (experimental)	
% Salt Product (experimental) Mass Salt (Product) / Mass Unknown x 100 =	
% Mass Salt Product *(based on Molar Mass)* Choose closest from the 4 possible (*lab calculations*)	
Identification of Unknown	

Calculations:

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

Theoretical Yield:

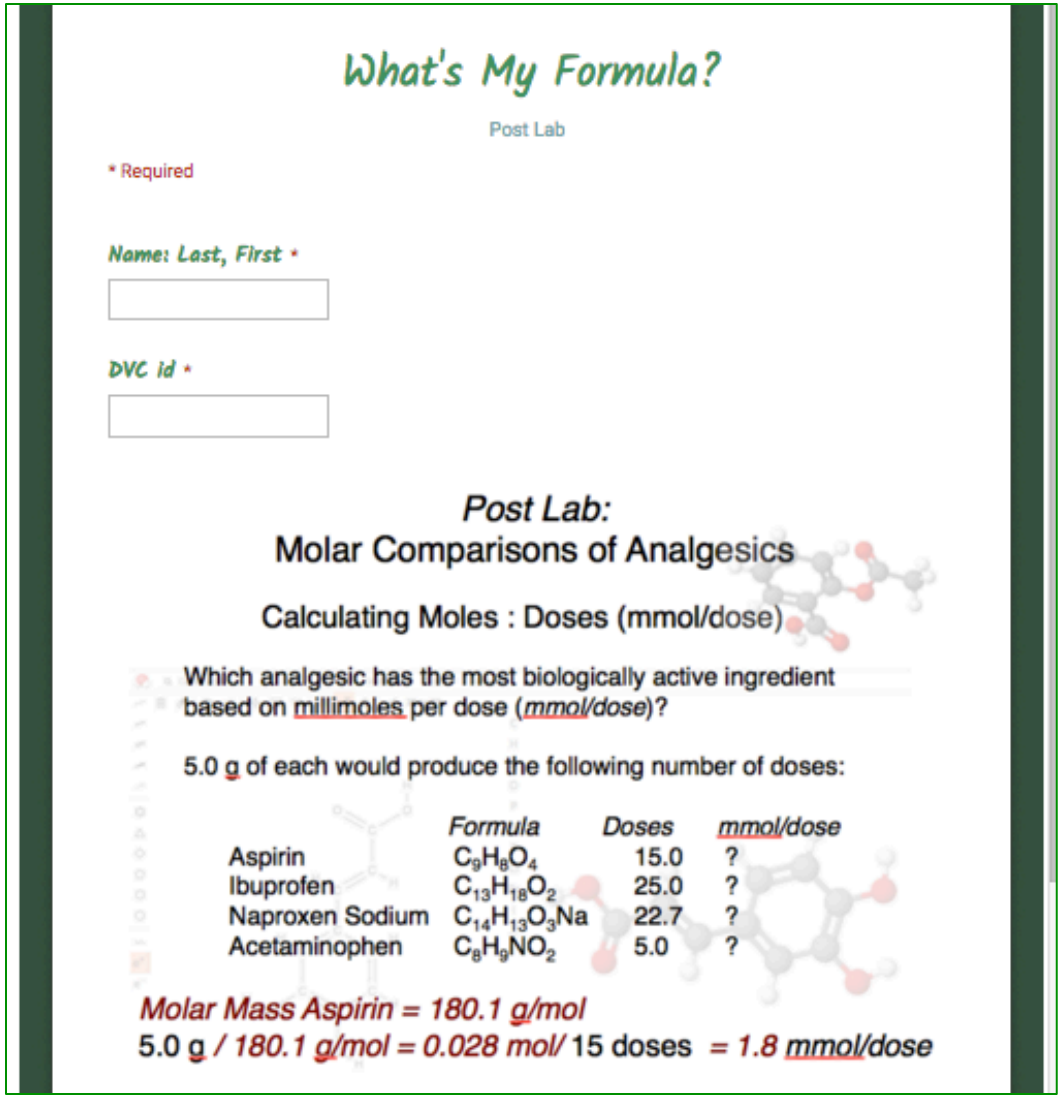
% Yield = actual grams of Salt (Product) / "Theoretical " grams x 100

36

When your Group has completed the Mass % calculations, bring all of the completed pages to Dr. R. to get your unknowns.

On-line Post Lab: submit by end of next week

http://chemconnections.org/general/chem108/What's%20My%20Formula.html



What's My Formula?

Post Lab

* Required

Name: Last, First *

DVC id *

Post Lab:
Molar Comparisons of Analgesics

Calculating 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	$C_9H_8O_4$	15.0	?
Ibuprofen	$C_{13}H_{18}O_2$	25.0	?
Naproxen Sodium	$C_{14}H_{13}O_3Na$	22.7	?
Acetaminophen	$C_8H_9NO_2$	5.0	?

Molar Mass Aspirin = 180.1 g/mol

5.0 g */ 180.1 g/mol = 0.028 mol/* 15 doses *= 1.8 mmol/dose*

What's My Formula? Identificaton

Unknowns

$BaCl_2 \cdot 2H_2O$

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

Unknown Sample — Salt

85.26%

$CaSO_4 \cdot 2H_2O$

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

Unknown Sample — Salt

79.09%

$NaHCO_3$

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

63.08%

Unknown Sample — Salt

$KHCO_3$

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

69.02%

Unknown Sample — Salt

Experimental Calculation: *(After completing the heatings)*

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

Comparison to Mass % Calculations for a, b, c, d