THE DISAPPEARING AND REAPPEARING ACT

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18 minutes to next solid line

Information: When a pure substance (an element or a compound) makes contact with water multiple changes can occur.

- The pure substance can dissolve in water. If this change occurs, the pure substance is said to be aqueous. For sugar, this can be represented as shown below (solid → aqueous).

  $$C_{12}H_{22}O_{11}(s) \rightarrow C_{12}H_{22}O_{11}(aq)$$

  For this process, individual sugar molecules are present in solution, but they are still intact.

- The pure substance can dissolve *and* produce ions in water.
  - This occurs with soluble ionic compounds. One example is table salt, NaCl. This change can be represented as shown below.

    $NaCl(s) \rightarrow NaCl(aq)$ (or $Na^+(aq)$ and $Cl^-(aq)$)

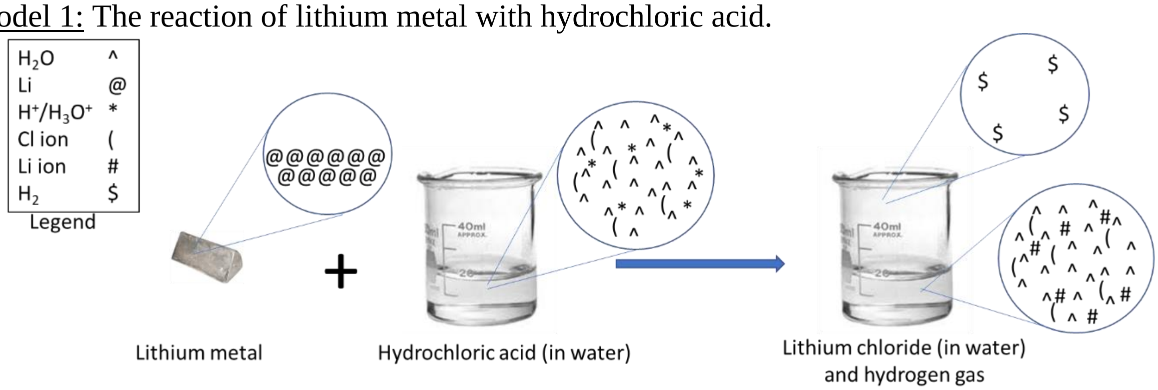
    It is important to realize that for a soluble ionic compound, the individual/separated ions are present in solution.
  - Acids also dissolve *and* produce ions in water. One example is the strong acid, HBr.

    $HBr(g) \rightarrow HBr(aq)$ (or $H^+(aq)$ and $Br^-(aq)$)

    The H^+ is often represented as H_3O^+ since it readily combines with an H_2O molecule.

- Many pure substances do not dissolve when making contact with water. This is the situation for insoluble substances such as calcium carbonate, $CaCO_3(s)$, and hydrogen gas, $H_2(g)$.

<u>Model 1:</u> The reaction of lithium metal with hydrochloric acid.



Balanced chemical equation $2Li(s) + 2HCl(aq) \rightarrow 2LiCl(aq) + H_2(g)$

<u>Key Questions:</u>

1. One of the reactants is lithium metal. What is the state for lithium metal (solid, liquid, or gas)? _solid_ Describe the arrangement of the individual particles (or atoms) in lithium metal?

   Organized in rows and close together

2. The other reactant is hydrochloric acid in water. What are the two substances produced when HCl makes contact with water (see beaker on reactant side)? _Cl ions_ and _H_3O^+_ Describe the arrangement of the individual particles (in this case ions) in water?

   They're kind of random and farther apart from each other and surrounded by water

   HCl is a *strong acid*. All strong acids react completely with water to produce hydronium (H_3O^+) and the associated anion. A strong acid, such as HNO_3, will produce H_3O^+ and the associated polyatomic ion (NO_3^- in this case).

3. Combining lithium metal with hydrochloric acid in water produces the products illustrated on the right.
   a. What are the two products produced from this reaction? _Lithium chloride (in water)_ and _hydrogen gas_.
   b. Is the hydrogen gas present in the water? _No_ Describe the arrangement of these particles.

      Very distant from each other and a random order

   c. Is the lithium chloride present in the water? _Yes_ What will be state of lithium chloride? _aqueous_ What are the particles present in water from lithium chloride? _Li and Cl ions_ Describe the arrangement of these particles.

      Separated from each other by water and a random order

   d. How did you know lithium chloride would be aqueous and not a solid in water? Use the table with solubility rules at the end of the laboratory activity.

      If it contains the Li ion it will be soluble, no exceptions

4. A representation of the reaction using chemical symbols is given in the model. The same number of each atom type must be on both sides of the reaction. In order to satisfy this requirement, coefficients are placed in front of the formulas (circled). This produces a *balanced chemical equation*. What is the coefficient in front of each substance in the balanced chemical equation? Also, indicate the state of each reactant and product (solid, liquid, gas, or aqueous).

Substance	**Coefficient**	**State**
Li	2	aqueous
HCl	2	aqueous

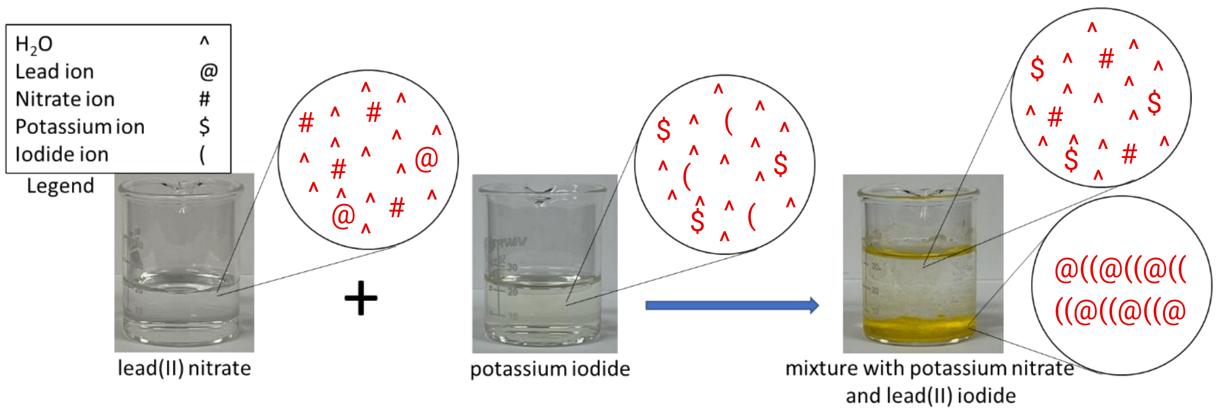
LiCl	2	aqueous
H_2	2	gas

The reaction shown above is a <u>single displacement (or replacement) reaction</u>. It occurs when an element (in this case lithium metal) "displaces" another element from a compound (in this case hydrogen), forming a new element and a new compound. If the displacing element is a metal, it displaces another metal or it displaces hydrogen (forming hydrogen gas) from a compound. If the displacing element is a nonmetal, it displaces another nonmetal. You need to remember to represent elements in their natural states (e.g. fluorine would be F_2 and hydrogen would be H_2).

<u>Exercises:</u>

Information: <u>Double-replacement reactions</u> are reactions in which the positive and negative ions of two ionic compounds exchange places to form two new compounds.

5. The double replacement reaction between aqueous lead(II) nitrate and aqueous potassium iodide is depicted below. The solid precipitate is yellow.



$Pb(NO_3)_2(aq) + 2KI(aq) \rightarrow PbI_2(s) + 2KNO_3(aq)$ Balanced chemical equation

a. Based on the solubility rules at the end of the activity, how can you tell PbI_2 will be a solid and KNO_3 will be aqueous?

If it contains I, then it is usually soluble except when its with Pb then its insoluble and therefore solid.

If it contains K, then it is always soluble, no exceptions, therefore aqueous.

b. In the empty circles, indicate the arrangement of particles.

<u>Entire class discussion:</u>

<u>Method development</u>:

<u>Items needed for *each* member of the group</u>: 1.50 M acetic acid solution (1 container per group), magnesium strips (containers on first bench), 50 mL graduated cylinder, 150 mL beaker, thermometer, and stirring rod.

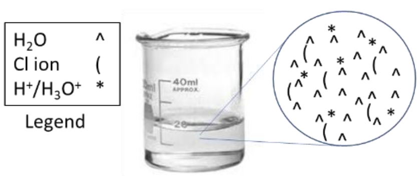
6. The first reaction performed will be between magnesium metal and aqueous acetic acid ($HC_2H_3O_2$). This is a single displacement reaction with the products being hydrogen gas and aqueous magnesium acetate (see balanced chemical equation).

$Mg(s) + 2HC_2H_3O_2(aq) \rightarrow Mg(C_2H_3O_2)_2(aq) + H_2(g)$

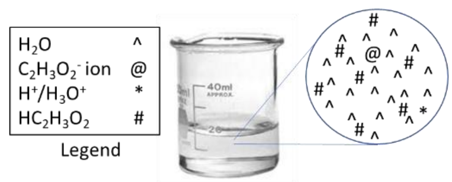
a. How can you tell this is a single displacement reaction by looking at the chemical equation?

The first H on the acetic acid is replaced by the Mg, like they swap places

b. Unlike HCl acid discussed above in the model, $HC_2H_3O_2$ is a weak acid. Below is a representation of HCl (a strong acid) and $HC_2H_3O_2$ (a weak acid) in water. Describe the difference between the dissociation of the two acids in water.



Hydrochloric acid (in water)



Acetic acid (in water)

All the HCl is broken into the separate ions, while only some of the acetic acid is broken into the separate ions

You should have noticed that most of the acetic acid molecules remain intact in water whereas all of the HCl molecules dissociate.

7. Examine the reactants and describe them.

a. Magnesium metal

Solid, metal, shiny

b. Acetic acid (1.50 M)

Aqueous, clear, looks just like water

8. Describe a method to perform the reaction above between magnesium metal and acetic acid. DO NOT PERFORM THE REACTION YET!

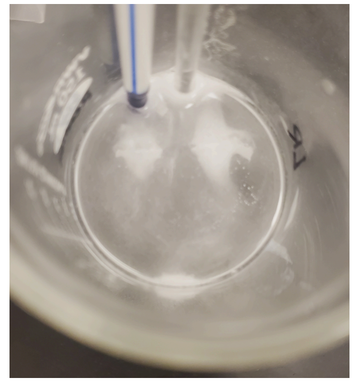
Measure out some of the acid an put it in a beaker, then put out a measured amount of magnesium and place it into the acid in the beaker

<u>Individual data collection (each person in the group will acquire their own data):</u>

9. The below information will assist you in performing the reaction between magnesium metal and aqueous acetic acid. Place the information in the table.

a. Perform the reaction in a clean 150 mL beaker. Label the beaker “REACTION” and with your initials.

b. Weigh out, in the beaker, between 0.18 and 0.20 g of magnesium strips. Place the mass in table below.
c. Measure out 17-19 mL of acetic acid solution (1.50 M) for the reaction. Place the volume in table below.
d. Time the reaction in seconds. Take a clear picture while the reaction is in progress.
e. Stir the reaction frequently to speed up the reaction. Record the maximum temperature of the reaction. The reaction is complete when the magnesium strips are gone. DO NOT DISPOSE OF THE SOLUTION IN THE BEAKER. IT WILL BE USED LATER.



10. Place the reaction information in the table below.

Mass of magnesium strips (in grams)	0.185 g
Volume of acetic acid solution (in mL)	18 mL
Time of reaction (seconds)	409 sec
Maximum temperature (°C)	43 degrees C

11. What did you observe while the reaction was occurring?

There were bubbles forming around the magnesium, the temperature rose to a max but then went back down slowly, the magnesium slowly dissolved into the solution and it remained clear besides the bubbles

12. Describe the contents in the REACTION beaker *after* the reaction is complete.

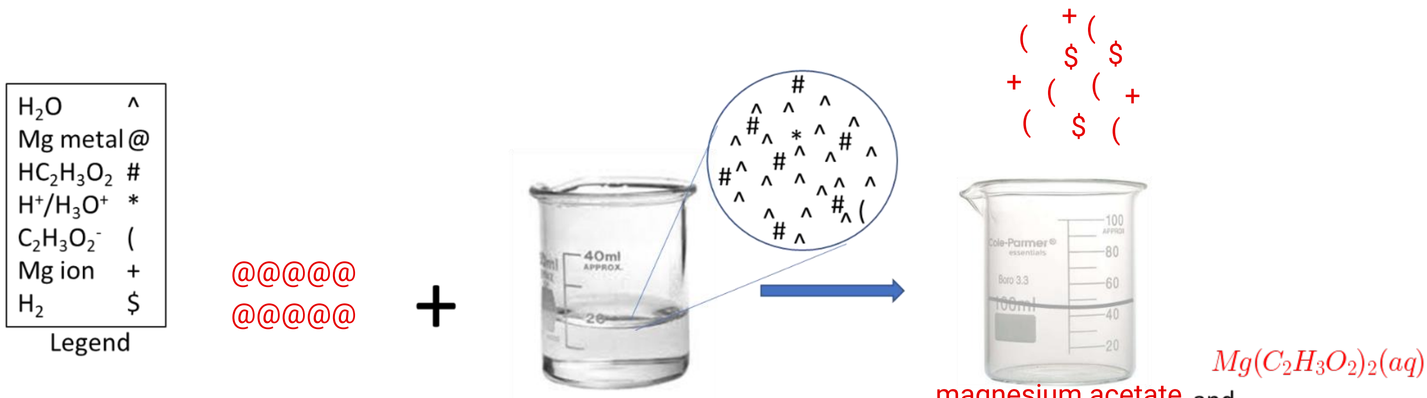
aqueous magnesium acetate, and then hydrogen gas that went out into the air

13. What happened to the magnesium metal?

It dissolved in the acetic acid and replaced the hydrogen to form magnesium acetate

14. Create a representation for the reaction of magnesium metal and acetic acid to form the products. Use Model 1 as a guide. Your representation will include drawings of the reactants and products as well as circles illustrating the arrangement of particles at the microscopic level. Acetic acid in water is already done.

$Mg(s) + 2HC_2H_3O_2(aq) \rightarrow Mg(C_2H_3O_2)_2(aq) + H_2(g)$



Magnesium metal $Mg\,(s)$

Acetic acid (in water)

magnesium acetate and hydrogen gas

$Mg(C_2H_3O_2)_2(aq)$

$H_2\,(g)$

15. Convert the mass of magnesium strips in the table above to moles. Show your work and use dimensional analysis.

$$\frac{0.185\text{ g}}{24.305\text{ g/mol}} = 0.00761 \text{ moles magnesium}$$

16. The coefficients in the balanced chemical equation must be used to determine the moles of product formed from a reactant. This is shown below for $Mg(C_2H_3O_2)_2$ forming from Mg. The coefficient for Mg is 1, and the coefficient for $Mg(C_2H_3O_2)_2$ is 1 as well. Input the calculated moles of Mg from above and perform the calculation.

$$\underline{1}Mg(s) + \underline{2}HC_2H_3O_2(aq) \rightarrow \underline{1}Mg(C_2H_3O_2)_2(aq) + \underline{1}H_2(g)$$

coefficients

$$\underline{0.00761}\ moles\ Mg \times \frac{1\ mole\ Mg(C_2H_3O_2)_2}{1\ mole\ Mg} = \underline{0.00761\text{ moles Mg(C2H3O2)2}}$$

Let's make sure you understand this. Suppose that you used 0.0300 moles of $HC_2H_3O_2$ for the reaction. How many moles of H_2 could be produced? Set this up in the same way as above and perform the calculation.

$$0.0300\ moles\ HC_2H_3O_2 \times \frac{1\text{ mole H2}}{2\text{ moles HC2H3O2}} = \underline{0.015\text{ moles H2}}$$

Ask the teacher or lab assistant to check your work before proceeding.

<u>Compilation of group data and group analysis:</u>

17. In the table below, input the maximum temperature for each group member (including your own) and then calculate an average temperature for your group.

	Maximum temperature (°C)
Group member	41

Group member	43
Group member	43
Group member	44
AVERAGE VALUE	42.75

18. About how long did it take for the reaction to go to completion? 6.5 minutes Discuss this among your group members and come up with an approximate average value.
19. In the aqueous compound, magnesium acetate, magnesium has a +2 charge. How did you know this?

    Acetate has a -1 charge and there are 2 of them, so for the net charge to be 0, magnesium would have a +2 charge. It's also in the 2nd column of the periodic table and all those elements have a +2 charge

INFORMATION: From the reaction performed above, you have aqueous magnesium acetate in the beaker. There is also acetic acid since it is in excess. The next step involves adding aqueous sodium carbonate to the mixture. The sodium carbonate reacts with the acetic acid (called Reaction 1) *and* with the magnesium acetate (called Reaction 2).

Reaction 1: $Na_2CO_3(aq) + 2HC_2H_3O_2(aq) \rightarrow H_2CO_3(aq) + 2NaC_2H_3O_2(aq)$

Reaction 2: $Na_2CO_3(aq) + Mg(C_2H_3O_2)_2(aq) \rightarrow MgCO_3(s) + 2NaC_2H_3O_2(aq)$

Method development:

Items needed for *each* member of the group: sodium carbonate (containers on first bench), scoopula, stirring rod, 50 mL beaker, disposable transfer pipette (pipettes on first bench), strainer, and coffee filter (filters on first bench), and 150 mL beaker.

20. Reaction 1: Aqueous sodium carbonate reacts with the excess acetic acid.
    a. How do you know that sodium carbonate will dissolve when placed in water?

       It contains Na and that means it's always soluble, so it will dissolve

    b. How do you know this is a double replacement reaction.

       The sodium in sodium carbonate is replaced with hydrogen, and the hydrogen in acetic acid is replaced with sodium so it's a double replacement

    c. One of the products is $H_2CO_3(aq)$. This product is unstable and immediately decomposes into $H_2O(l)$ and $CO_2(g)$. Write the balanced chemical equation including these decomposition products *instead of* $H_2CO_3(aq)$.

       $Na_2CO_3(aq) + 2HC_2H_3O_2(aq) \rightarrow 2NaC_2H_3O_2(aq) + H_2O\,(l) + CO_2\,(g)$

21. Reaction 2: Aqueous sodium carbonate also reacts with aqueous magnesium acetate. This reaction is also double replacement.

a. How do know the ionic compound, $MgCO_3$, will be a solid precipitate?

Since it contains CO3 it will be insoluble

b. How do you know $NaC_2H_3O_2$ will be aqueous?

It contains Na so it will be soluble

22. Describe a method to perform the reactions above.

Dissolve the sodium carbonate in water and then add it to the magnesium acetate so it will do each of the reactions

Individual data collection (each person in the group will acquire their own data):

23. The below information will assist you in performing Reaction 1 and Reaction 2 specified previously.
    a. Measure out between 1.6 and 1.7 grams of solid sodium carbonate in a 50 mL beaker (record the mass below).
    b. *Fully* dissolve the sodium carbonate in approximately 15 mL of distilled water. Mix with stirring rod. Note: This will take a few minutes.

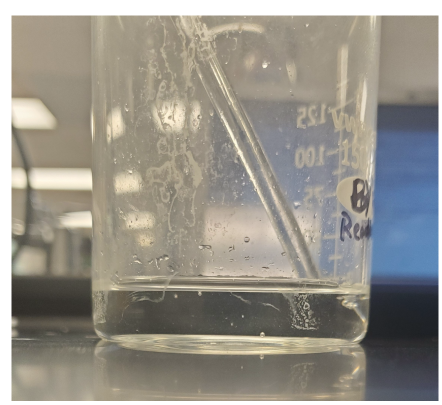
Mass of sodium carbonate in grams	1.627

24. The aqueous sodium carbonate will be added incrementally using the transfer pipette. It is imperative that detailed observations are recorded after each addition.

    a. Press the bulb and allow sodium carbonate to fill the pipette. This is one aliquot. While stirring, add this *one* aliquot dropwise to the beaker containing the acetic acid and magnesium acetate (beaker labeled REACTION).
        i. Write down your observations.

For each drop added, It bubbled a little, making it appear whitish but then went back to how it looked before. By the end of the one aliquot, it went back to looking the same slower than at the beginning

        ii. Describe the appearance of the contents in the beaker *after* adding the one aliquot. Take a clear picture with your camera.



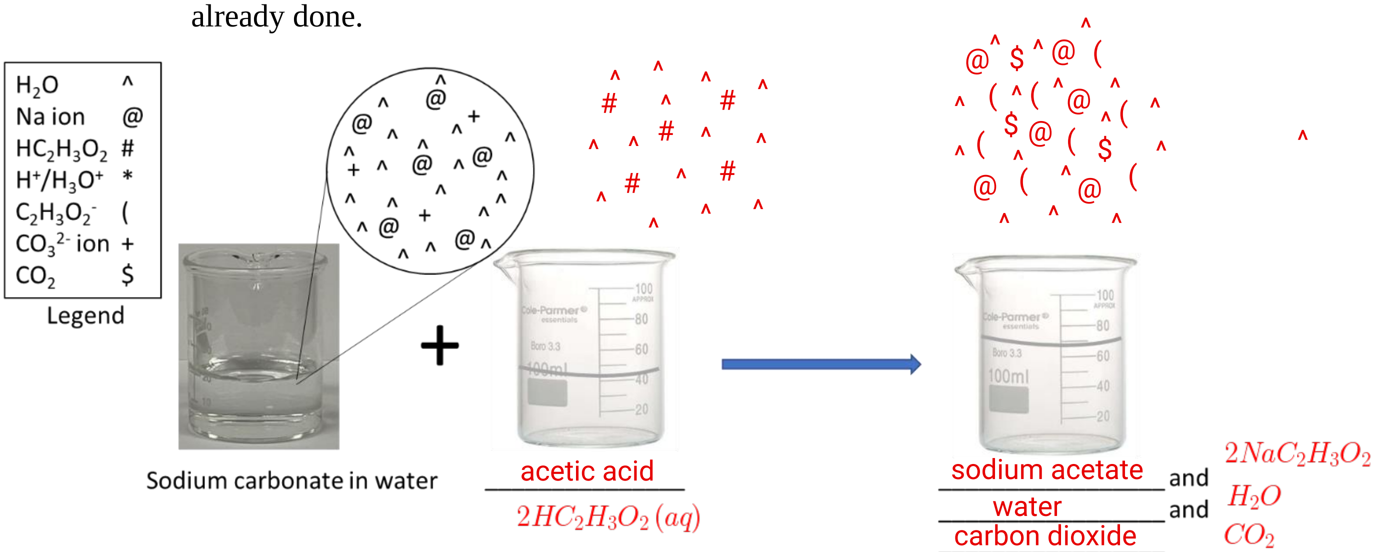
It looks basically the same as it did before, but it now has little bubbles coming up occasionally

iii. Discuss the observations with your group members. There should be consensus with what was observed.

iv. Based on observations and the appearance of the contents in the beaker, which reaction was predominant with just one aliquot of $Na_2CO_3(aq)$ (Reaction 1 or Reaction 2)? Reaction 1

v. What is the identity of the gaseous product? carbon dioxide

b. Create a representation for the reaction observed above (this will be Reaction 1 *or* Reaction 2). Your representation will include drawings of the reactants and products as well as circles illustrating the arrangement of particles at the microscopic level (see Model 1 for an example). Sodium carbonate in water is already done.



c. Add *one more* aliquot of $Na_2CO_3(aq)$, dropwise, to the Reaction beaker while stirring.

i. Write down your observations.

It took longer for each drop to completely react, it sat in there longer

ii. Describe the appearance of the contents in the beaker *after* adding the aliquot.

Similar to how it was previously, but more bubbles continue to come up, like if it were a carbonated drink

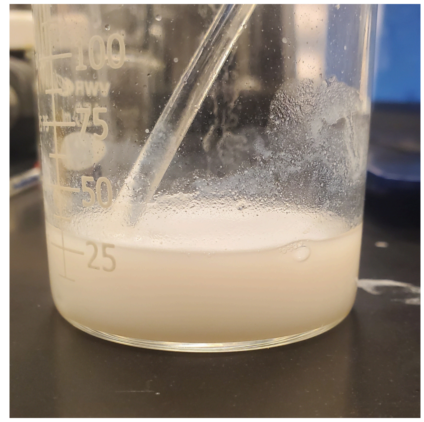
iii. Based on your observations and the appearance of the contents in the beaker, which reaction took place (Reaction 1 or Reaction 2)?

Reaction 1

d. Add the remaining amount of $Na_2CO_3(aq)$ via aliquots with the transfer pipette while stirring.

i. Write down your observations.

It continued to get more and more white and less clear



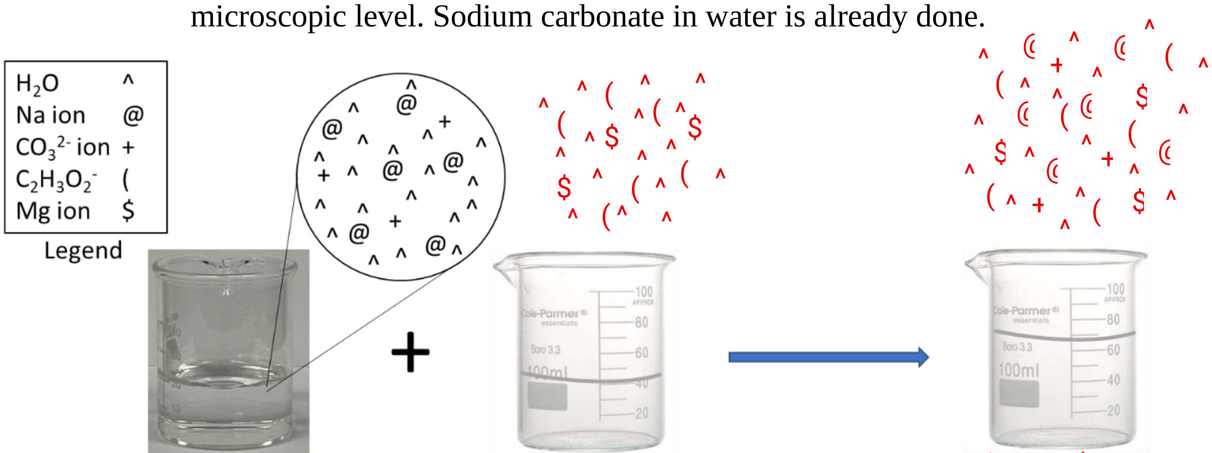
ii. Describe the appearance of the contents in the beaker *after* adding the remaining $Na_2CO_3(aq)$. Take a clear picture with your camera.

Its completely white and not clear any more

iii. Based on the observations and the appearance of the contents in the beaker, which reaction took place (Reaction 1 or 2)? Reaction 2

iv. What is the identity of the white solid? Mg Carbonate Note: The solid will eventually settle to the bottom of the beaker.

e. Create a representation for the reaction observed above (this will be Reaction 1 *or* Reaction 2). Your representation will include drawings of the reactants and products as well as circles illustrating the arrangement of particles at the microscopic level. Sodium carbonate in water is already done.



Sodium carbonate in water + magnesium acetate $Mg(C_2H_3O_2)_2\,(aq)$ → magnesium carbonate $MgCO_3\,(s)$ and sodium acetate $2NaC_2H_3O_2\,(aq)$

25. You need to separate the solid in your beaker from the liquid and determine its mass. This will be accomplished using filtration. The below information will assist you in performing the filtration and determining the mass of the solid. Record the specified information in the table below.

a. Acquire the mass of one coffee filter (place this mass in the table).
b. Place the coffee filter in the wire strainer and place strainer on top of a 150 mL beaker.
c. Gradually pour the contents of the REACTION beaker into the filter making sure that the liquid does not flow over the top of the filter.
d. Wait a few minutes for most of the liquid to pass through the filter.
e. Transfer more of the remaining solid product and rinse it by performing the following steps.

i. Add about 5 milliliters of water to the REACTION beaker.

ii. Mix well with the spatula.
iii. Pour mixture into the filter.
iv. Wait five minutes for most of the liquid to pass through the filter.

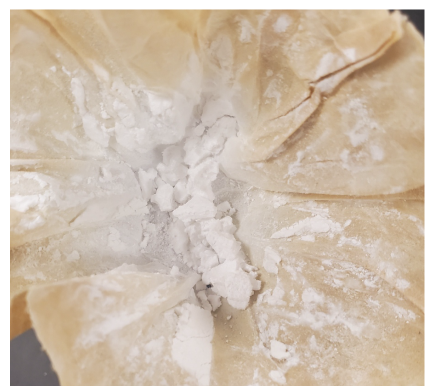
f. Label a 50 mL beaker with your initials.
g. Remove *most* of the excess liquid from your product by gently squeezing the filter from the top. Open the filter and place the filter with the collected solid in the labeled 50 mL beaker labeled (see picture). Place this beaker (with the solid) in the provided tray. Your teacher will place the tray in the oven at 415°F (213°C) for 20 minutes. You are encouraged to work on the problems in Application of Principles while waiting.

h. Carefully remove the filter with the solid from the 50 mL beaker and acquire a mass of the filter with the solid (place this mass in the table below).
i. Determine the mass of the dry solid.

26. Fill in the following table:

Mass of coffee filter	0.230 g
Mass of coffee filter and dry $MgCO_3$	0.937 g
Mass of dry $MgCO_3$ (actual yield)	0.707 g

27. Describe the solid product in the filter. You are allowed to touch it. Take a clear picture with your camera.



It's like a white clumpy powder

28. The amount of $MgCO_3$ in the coffee filter (see table above) is the *actual yield*. The *theoretical yield* $MgCO_3$ is calculated from the moles of $Mg(C_2H_3O_2)_2(aq)$ determined previously. Perform this calculation. Show your work and use dimensional analysis.

$$0.00761 \text{ moles } Mg(C2H3O2)2 \times \frac{1 \text{ mole } MgCO3}{1 \text{ mole } Mg(C2H3O2)2} = 0.00761 \text{ moles } MgCO3$$

Convert this theoretical yield in moles of $MgCO_3$ to grams.

$$0.00761 \text{ moles } MgCO3 \times 84.314 \text{ g/mol } MgCO3 = 0.642 \text{ g}$$

29. Calculate the percent yield for the reaction to produce $MgCO_3$ using the equation below.

$$percent\ yield = \frac{actual\ yield}{theoretical\ yield} \times 100.0\% \qquad \frac{0.707}{0.642} \cdot 100\% = 110\%$$

Compilation of group data and group analysis:

30. In the table below, input the percent yield for each group member (including your own) and then calculate and average for your group.

	Percent yield
Group member	110 %
Group member	30.5 %
Group member	51.7 %
Group member	96.2 %
AVERAGE VALUE	72.1 %

31. Is the group's average value significantly below 100% (< 50%) or significantly above 100% (>150%)? No If it is, provide a reason.

Class data: In the class data sheet (link in Canvas), input the average value for percent yield.

Make sure all items are clean and return them to the drawer or bench. Finish cleaning any glassware used by rinsing with distilled water. Before you leave, ask the teacher or lab assistant to examine your data and laboratory space. Note: Your data must be entered into the spreadsheet before you leave.

Application of principles (to be completed individually):

32. Write the correct formula for copper(II) sulfate.

$CuSO_4$

33. Classify the following reactions as decomposition, combination, single replacement, or double replacement.

Reaction	**Reaction Type**
$6HCl(aq) + 2Al(s) \rightarrow 3H_2(g) + 2AlCl_3(aq)$	single replacement
$2KClO_3(s) \rightarrow 3O_2(g) + 2KCl(s)$	decomposition

$Na_2S(aq) + Cu(NO_3)_2(aq) \rightarrow 2NaNO_3(aq) + CuS(s)$	double replacement
$S_8(s) + 24Cl_2(g) \rightarrow 8SCl_6(g)$	combination

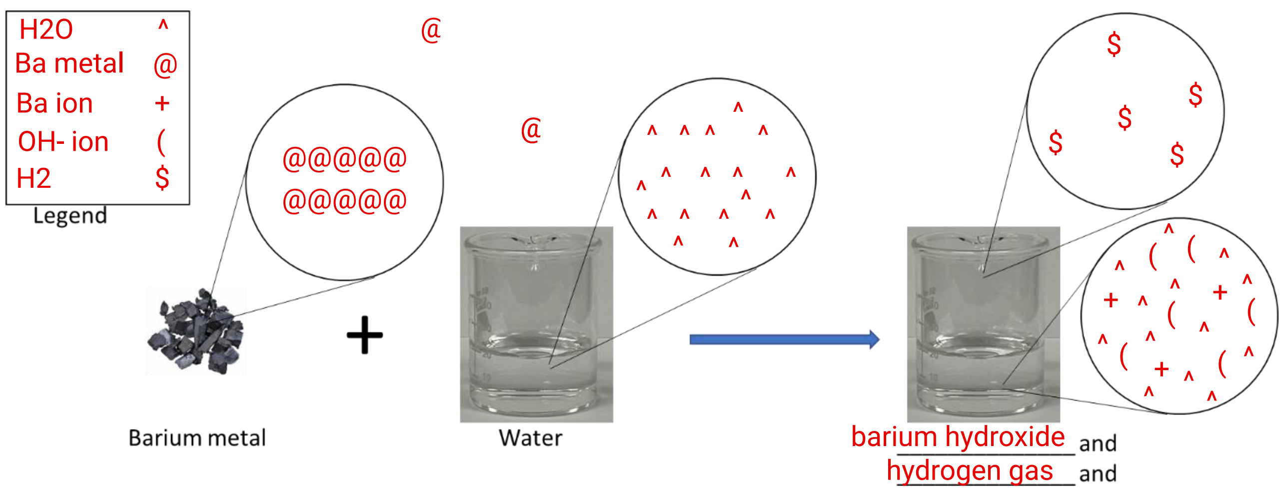
34. A single replacement reaction occurs between barium metal and water.

   $Ba(s) + 2H_2O(l) \rightarrow Ba(OH)_2(aq) + H_2(g)$

   a. How many moles of water are required to react with one mole of barium metal?

   2

   b. Create a representation for the reaction observed above. Your representation will include drawings of the reactants and products as well as circles illustrating the arrangement of particles at the microscopic level. You will also need to create a legend.



   c. Using the balanced chemical equation, determine the moles of the gaseous product formed when 0.6291 grams of barium reacts with excess water? You must show your work by writing below or inserting a picture of your work. Use dimensional analysis.

$$\frac{0.6291 \text{ g barium}}{137.33 \text{ g/mol barium}} = 0.004581 \text{ mol barium} \times \frac{1 \text{ mol H2}}{1 \text{ mol barium}} = 0.004581 \text{ mol H2}$$

35. The first reaction performed in this laboratory was between acetic acid and magnesium metal to form hydrogen gas and magnesium acetate. The hydrogen gas produced from this reaction can react with oxygen gas to produce water vapor. Write this latter reaction, balance it, and indicate the type of reaction.

   $2H_2\,(g) + O_2\,(g) = 2H_2O\,(g)$ combination

36. If your percent yield is below 40% or above 100% suggest a reason.

My filter broke while i was squeezing the liquid out so things got a little messed up then

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1 **H** 1.008																	2 **He** 4.0026
3 **Li** 6.94	4 **Be** 9.0122											5 **B** 10.81	6 **C** 12.011	7 **N** 14.007	8 **O** 15.999	9 **F** 18.998	10 **Ne** 20.180
11 **Na** 22.990	12 **Mg** 24.305											13 **Al** 26.982	14 **Si** 28.085	15 **P** 30.974	16 **S** 32.06	17 **Cl** 35.45	18 **Ar** 39.948
19 **K** 39.098	20 **Ca** 40.078	21 **Sc** 44.956	22 **Ti** 47.867	23 **V** 50.942	24 **Cr** 51.996	25 **Mn** 54.938	26 **Fe** 55.845	27 **Co** 58.933	28 **Ni** 58.693	29 **Cu** 63.546	30 **Zn** 65.38	31 **Ga** 69.723	32 **Ge** 72.630	33 **As** 74.922	34 **Se** 78.97	35 **Br** 79.904	36 **Kr** 83.798
37 **Rb** 85.468	38 **Sr** 87.62	39 **Y** 88.906	40 **Zr** 91.224	41 **Nb** 92.906	42 **Mo** 95.95	43 **Tc** (98)	44 **Ru** 101.07	45 **Rh** 102.91	46 **Pd** 106.42	47 **Ag** 107.87	48 **Cd** 112.41	49 **In** 114.82	50 **Sn** 118.71	51 **Sb** 121.76	52 **Te** 127.60	53 **I** 126.90	54 **Xe** 131.29
55 **Cs** 132.91	56 **Ba** 137.33	57-71 *	72 **Hf** 178.49	73 **Ta** 180.95	74 **W** 183.84	75 **Re** 186.21	76 **Os** 190.23	77 **Ir** 192.22	78 **Pt** 195.08	79 **Au** 196.97	80 **Hg** 200.59	81 **Tl** 204.38	82 **Pb** 207.2	83 **Bi** 208.98	84 **Po** (209)	85 **At** (210)	86 **Rn** (222)
87 **Fr** (223)	88 **Ra** (226)	89-103 #	104 **Rf** (265)	105 **Db** (268)	106 **Sg** (271)	107 **Bh** (270)	108 **Hs** (277)	109 **Mt** (276)	110 **Ds** (281)	111 **Rg** (280)	112 **Cn** (285)	113 **Nh** (286)	114 **Fl** (289)	115 **Mc** (289)	116 **Lv** (293)	117 **Ts** (294)	118 **Og** (294)

* Lanthanide series	57 **La** 138.91	58 **Ce** 140.12	59 **Pr** 140.91	60 **Nd** 144.24	61 **Pm** (145)	62 **Sm** 150.36	63 **Eu** 151.96	64 **Gd** 157.25	65 **Tb** 158.93	66 **Dy** 162.50	67 **Ho** 164.93	68 **Er** 167.26	69 **Tm** 168.93	70 **Yb** 173.05	71 **Lu** 174.97
# Actinide series	89 **Ac** (227)	90 **Th** 232.04	91 **Pa** 231.04	92 **U** 238.03	93 **Np** (237)	94 **Pu** (244)	95 **Am** (243)	96 **Cm** (247)	97 **Bk** (247)	98 **Cf** (251)	99 **Es** (252)	100 **Fm** (257)	101 **Md** (258)	102 **No** (259)	103 **Lr** (262)

	Contain these ions	EXCEPTIONS
Soluble Ionic Compounds	NH_4^+ group I cations: Li^+ Na^+ K^+ Rb^+ Cs^+	none
	Cl^- Br^- I^-	compounds with Ag^+, Hg_2^{2+}, and Pb^{2+}
	F^-	compounds with group 2 metal cations, Pb^{2+}, and Fe^{3+}
	$C_2H_3O_2^-$ HCO_3^- NO_3^- ClO_3^-	none
	SO_4^{2-}	compounds with Ag^+, Ba^{2+}, Ca^{2+}, Hg_2^{2+}, Pb^{2+} and Sr^{2+}
Insoluble Ionic Compounds	**Contain these ions**	**EXCEPTIONS**
	CO_3^{2-} CrO_4^{2-} PO_4^{3-} S^{2-}	compounds with group 1 cations and NH_4^+
	OH^-	compounds with group 1 cations and Ba^{2+}
Ionic compounds not in the table are usually insoluble		