Chemistry

Unit 4:Chemical Reactions

Workbook 4

Name: ______________________________ Period: ______

Guiding Question:	
Do Now:	
Important Definitions and Equations:	**Notes:** Chemical equations represent changes in matter using symbols and formulas. They also indicate what state of matter each chemical is in. Recall (s) = ________________, (l) = ________________ , (g) = ___________, and (aq) =________________(dissolved in water). •These equations allow you to see what is happening to matter at an atomic level. •They do not tell you how fast the change will happen, if it will happen at all, nor all of the things you may observe (color changes, heat, fire, etc.) __________________________: A change in matter in which a substance changes form but not identity. Examples: __________________________: A change in matter that results in the formation of a new substance or substances with new properties. Examples: Check in: What would you expect to observe in the following reaction based on the information given? $CoCl_2(aq) + Ca(OH)_2(aq) \rightarrow Co(OH)_2(s) + CaCl_2(aq)$
Response:	

15 Spare Change

Physical vs. Chemical Change

Purpose

To learn to distinguish between physical and chemical changes

Part 1: Classifying Change

Use the table to help you answer the questions

Physical change	?	Chemical change
$H_2O(l) \longrightarrow H_2O(s)$	$NaCl(s) \longrightarrow NaCl(aq)$	$S(s) + O_2(g) \longrightarrow SO_2(g)$
$Br_2(l) \longrightarrow Br_2(g)$	$C_6H_{12}O_6(s) \longrightarrow C_6H_{12}O_6(aq)$	$CH_4(g) + 2O_2(g) \longrightarrow CO_2(g) + 2H_2O(l)$
$CO_2(s) \longrightarrow CO_2(g)$	$CoCl_2(s) \longrightarrow CoCl_2(aq)$	$CaCO_3(s) \longrightarrow CaO(s) + CO_2(g)$

1. Examine all of the equations in the first column. Name two things that they have in common.

2. What do the equations in the third column have in common?

3. What do the equations in the middle column describe?

4. How would you define physical change? Use information from the table.

5. How would you define chemical change? Use the information from the table.

6. When something dissolves, would you classify it as a physical or a chemical change? Explain your thinking.

7. Examine these four chemical equations. Place each in its appropriate column on the table on the previous page.

$$C_3H_8(g) + 5O_2(g) \longrightarrow 3CO_2(g) + 4H_2O(l)$$
$$C_2H_6O(l) \longrightarrow C_2H_6O(g)$$
$$CaSO_4(aq) \longrightarrow CaSO_4(s)$$
$$NaCl(aq) + AgNO_3(aq) \longrightarrow NaNO_3(aq) + AgCl(s)$$

Part 2: Physical or Chemical Change

The table lists several equations

1. Write P or C next to each equation to indicate whether it represents a physical change or a chemical change.

Equations from Lesson 2: Making Predictions	P or C?
1. $CO_2(s) \longrightarrow CO_2(g)$	
2. $CO_2(s) + H_2O(l) \longrightarrow H_2CO_3(aq)$	
3. $Ca(OH)_2(aq) + CO_2(s) \longrightarrow CaCO_3(s) + H_2O(l)$	
4. $CaCl_2(s) \longrightarrow CaCl_2(aq)$	
5. $CaCl_2(aq) + 2NaOH(aq) \longrightarrow Ca(OH)_2(s) + 2NaCl(aq)$	
6. $CaCl_2(s) + CuSO_4(s) \longrightarrow CaCl_2(s) + CuSO_4(s)$	
7. $CuSO_4(s) \longrightarrow CuSO_4(aq)$	
8. $CuSO_4(s) + 4NH_4OH(aq) \longrightarrow Cu(NH_3)_4SO_4(aq) + 4H_2O(l)$	
9. $CuSO_4(aq) + Zn(s) \longrightarrow Cu(s) + ZnSO_4(aq)$	

2. What evidence did you use to help you decide whether to write P or C?

3. **Making Sense** If you were asked to classify a reaction as a physical change or a chemical change, which would you prefer to have: a set of observations or the chemical equation? Explain your thinking.

Guiding Question:	
Do Now:	
Important Definitions and Equations:	**Notes:** ___________________________________: Matter cannot be created or destroyed. In a chemical reaction atoms do not come in and out of existence, they are simply rearranged. Because these atoms have mass, the mass does not change. • The only time that it may look like the mass has changed is when a gas is produced and leaves the system. If the reaction was done in a closed container, the mass would remain the same
Response:	

16 Some things never change

Conservation of Mass

Purpose

To explore changes in mass that may occur during physical or chemical changes

Materials

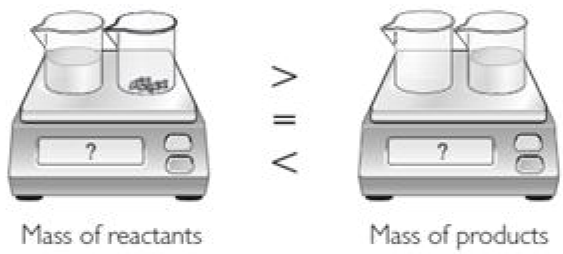
- Balance
- Clear plastic cups
- Water
- NaCl(s), 1 g
- 1.0 M Na_2CO_3(aq), 40 mL
- 1.0 M $CaCl_2$(aq), 20 mL
- Acetic acid, 20 mL
- Graduated cylinder

Part 1: Predict the Mass

For each equation, predict whether the reactants or products will have a greater mass by circling >, =, <. Write an explanation to try and convince your group.

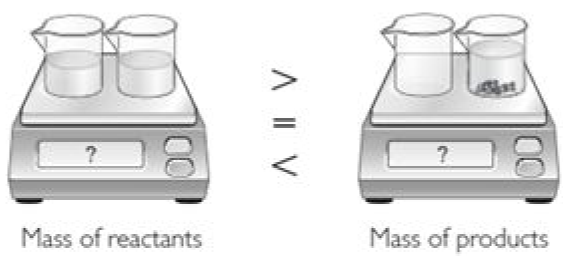
1. Water is added to solid sodium chloride to produce aqueous sodium chloride.

Equation 1: $NaCl(s) \longrightarrow NaCl(aq)$



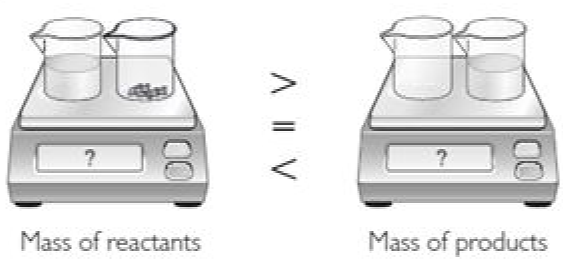
2. Aqueous sodium carbonate is added to aqueous calcium chloride to produce aqueous sodium chloride and solid calcium carbonate.

Equation 2:
$$Na_2CO_3(aq) + CaCl_2(aq) \longrightarrow 2NaCl(aq) + CaCO_3(s)$$



3. Aqueous sodium carbonate is added to aqueous acetic acid to produce aqueous sodium acetate, water, and carbon dioxide gas.

Equation 3:
$$Na_2CO_3(aq) + 2C_2H_4O_2(aq) \longrightarrow 2NaC_2H_3O_2(aq) + H_2O(l) + CO_2(g)$$



Part 2: Testing Your Predictions

Carry out each of the three changes described. Find the total mass before and after each change. Measure mass to the nearest tenth of a gram.

1. Put approximately 1 g of NaCl(s) in one cup. Put 20 mL of water in another cup.
   Equation 1: NaCl(s) → NaCl(aq)

Reactants	Chemical name	Description	Total mass before mixing
NaCl(*s*)			
$H_2O(l)$			

2. Combine the reactants

Products	Chemical name	Description	Total mass after mixing
NaCl(*aq*)			

3. Explain your observations. Do they match your predictions?

4. Why do you think water is not included as part of the chemical equation?

5. Put 20 mL of 1.0 M Na_2CO_3(aq) in one cup. Put 20 mL of 1.0 M $CaCl_2$(aq) in another cup.
   Equation 2: Na_2CO_3(aq) + $CaCl_2$(aq) → 2NaCl(aq) + $CaCO_3$(s)

Reactants	Chemical name	Description	Total mass before mixing
$Na_2CO_3(aq)$			
$CaCl_2(aq)$			

6. Combine the reactants

Products	Chemical name	Description	Total mass after mixing
$CaCO_3(s)$			
NaCl(*aq*)			

7. Explain your observations. Do they match your predictions?

8. Look at the chemical equation representing this change.

   a. What is the solid that formed?

   b. What is dissolved in solution?

   c. Did the number of atoms change between reactants and products?

9. Put 20 mL of 1.0 M $Na_2CO_3(aq)$ in one cup. Put 20 mL of $C_2H_4O_2(aq)$ in the other cup.

   Equation 3: $Na_2CO_3(aq) + 2C_2H_4O_2(aq) \rightarrow 2\ NaC_2H_3O_2(aq) + H_2O(l) + CO_2(g)$

Reactant	Chemical name	Description	Total mass before mixing
$Na_2CO_3(aq)$			
$C_2H_4O_2(aq)$			

10. Combine the reactants

Products	Chemical name	Description	Total mass after mixing
$NaC_2H_3O_2(aq)$			
$CO_2(g)$			

11. Explain your observations. Do they match your predictions?

12. Why do you think water *is* included as part of the chemical equation?

13. **Making Sense** Mass is conserved during physical and chemical changes. Explain what this means.

Guiding Question:	
Do Now:	
Important Definitions and Equations:	**Notes:** To show that atoms we start with are conserved in a chemical reaction, we need to make sure that the reaction is balanced A ________________________________shows that there is the same number of each atom on the reactant and product side of the equation. When balancing and equation we can change the ________________ but we cannot change what compounds are present or the _________________. $\_\_Na_2CO_3(aq) + \_\_CaCl_2(aq) \rightarrow \_\_NaCl(aq) + \_\_CaCO_3(s)$ Check in
Response:	

17 Atom Inventory

Balancing Chemical Equations

Purpose

To use the concept of mass conservation to balance chemical equations

Procedure and Questions

1. **Unbalanced equation 1:** $Zn(s) + HCl(aq) \rightarrow ZnCl_2(aq) + H_2(g)$
   a. Use the materials to build models of the reactants and products. Use a different color to represent each type of atom. Sketch your models here.

Inventory of Atoms	
Reactant side	Product side
___ Zn	___ Zn
___ H	___ H
___ Cl	___ Cl

Inventory of Atoms	
Reactant side	Product side
___ Zn	___ Zn
___ H	___ H
___ Cl	___ Cl

   b. Take an inventory of the atoms. Are there the same number of atoms on both sides of the equation?
   c. Add appropriate units of reactants and products to *balance* the equation. Each side should end up with the exact same number of atoms. Draw it below.
   d. Take another inventory of the atoms. If the equation is not balanced, repeat the previous step until the same number of each type of atom is on both sides of the equation.
   e. Write out the balanced chemical equation by indicating how many of each atom, molecule, or compound is needed. If only one atom or compound is needed, you do not need to write the number

2. Use the cubes to help you balance each equation. Draw it below:
   a. ___O_2(g) + ___H_2(g) → ___H_2O(l)

   b. ___CH_4(g) + ___O_2(g) → ___CO_2(g) + ___H_2O (l)

   c. ___NO_2(g) + ___H_2O (l) → ___HNO_3(aq) + ___NO(g)

Guiding Question:

Do Now:

Important Definitions and Equations:	**Notes:**
	Chemical reactions can be divided into categories based on how the atoms in the reactants rearrange to form the products. • __________________ reaction: Several reactants combine to form a single product. Combination reactions are easy to spot because there is only one compound on the product side of the equation. The general reaction can be written as Example: • _____________________reaction: A compound breaks down as a result of a chemical change. Decomposition reactions are easy to spot because there is on only one reactant. The general reaction can be written as Example: • ________________________ reaction: A compound breaks apart, and one part combines with another reactant – either an atom or a group of atoms (polyatomic ion). Typically, one of the reactants is an element. The general reaction can be written as Example: • ________________________ reaction: Both reactants break apart. Their parts then recombine into new products. Thus, the two reactants exchange parts. There general reaction can be written as Example: • ______________________ reaction: A reactant reacts with oxygen to produce water and carbon dioxide. The general reaction can be written as Example:

Response:

18 What's Your Reaction

Types of Reactions

Purpose To classify chemical reactions by reaction type

Part 1: Observing Chemical Reactions

1. Make predictions based on the chemical reaction as to what you think is happening in the boxes below.
2. Scan the code to the right or go to this link to watch the video.
3. Take observation notes below on what is happening to each reaction.
4. Determine the type of reaction based on the chemical formula.

Reaction	Observation	Type
Elephant Toothpaste $2H_2O_2 \rightarrow 2H_2O + O_2$		
$K_2CrO_4 + 2AgNO_3 \rightarrow Ag_2CrO_4 + 2KNO_3$		
Woosh Bottle $C_{2,}H_5OH + 3O_2 \rightarrow 2CO_2 + 3H_2O$		
$2HCl + Zn \rightarrow ZnCl_2 + H_2$		
$8Fe + S_8 \rightarrow 8FeS$		

Part 2: Classifying Reactions

1. Balance the following equations
2. Classify each equation as either combination, decomposition, single exchange, double exchange, or combustion.
3. Explain your choice for each

Reaction	Type	Explanation
____N_2(g) + ____H_2(g) → ____NH_3(g)		
____C_2H_4(g) + ____H_2(g) → ____C_2H_6(g)		
____$CaCO_3$(s) → ____Cao(s) + ____CO_2(g)		
__NaOH(aq)+__HCl(aq) → __H_2O(l)+__NaCl(s)		
____C_3H_8(l)+ ____O_2(g) → ____H_2O(l) +____CO_2(g)		
____$KClO_3$(s) → ____KCl(s)+ ____O_2(g)		
__$AgNO_3$(aq)+ __KCl(aq) → __AgCl(s)+ __KNO_3(aq)		

Guiding Question:

Do Now:

Important Definitions and Equations:	**Notes:**

Response:	

19 Blowing Up Moles

Mole Ratios in Reactions

Purpose

To investigate and determine the relationship between reactants and products in a reaction.

Materials

- 3 – Erlenmeyer Flasks
- 3 Balloons
- Baking Soda, $NaHCO_3$(s)
- Vinegar, $HC_2H_3O_2$ (aq)
- Scale
- 100mL Graduated Cylinder
- Scoopula
- Weigh Boat

Procedure

1. Check that all materials are clean
2. Pour 100mL of vinegar in each of the flasks
3. Measure out 3.5g of baking soda and carefully pour into one of the balloons.
4. Attach the balloon to Flask 1; do not let baking soda pour into the flask yet
5. Measure out 7.0g of baking soda and carefully pour into one of the balloons.
6. Attach the balloon to Flask 2; do not let baking soda pour into the flask yet
7. Measure out 14.0g of baking soda and carefully pour into one of the balloons.
8. Attach the balloon to flask 3; do not let the baking soda pour into the flask yet.
9. At the same time, lift the balloons to pour the baking soda into the flask
10. Record observations below (you may consider smelling the flasks after the reaction by wafting).

Clean Up:

- Remove balloons and place into a trash can
- Rinse Flasks out and leave inverted on a drying tray for next class
- Return lab station to initial setup. Return to seats and answer the remain lab questions

Observations

Flask 1	Flask 2	Flask 3

Questions

1. Using your observations and the reaction equation above (for the lab), explain why your balloon for flask 1 should be smaller than the balloon for flask 2.

2. Why is the balloon for flask 2 the same size as the balloon for flask 3 (or why should it be)? Think about what you changed and what you did not change.

3. What does your observations about this lab say about reactions between different reactants? Use the reaction equation above and your observations to help you answer this question.

Guiding Question:	
Do Now:	
Important Definitions and Equations:	**Notes:**
Response:	

20 Mole to Mole

Mole ratios

Why?

A balanced chemical equation can tell us the number of reactant and product particles (ions, atoms, molecules or formula units) that are necessary to conserve mass during a chemical reaction. Typically when we balance the chemical equation we think in terms of individual particles. However, in real life the reaction represented by an equation occurs an unimaginable number of times. Short of writing very large numbers (10^{23} or larger) in front of each chemical in the equation, how can we interpret chemical equations so that they more realistically represent what is happening in real life? In this activity you will explore the different ways a chemical reaction can be interpreted.

Model 1 – A Chemical Reaction

$$N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$$

1. Consider the reaction in Model 1.
   a. What are the coefficients for each of the following substances in the reaction?

      N_2 H_2 NH_3

   b. Draw particle models below to illustrate the reaction in Model 1.

2. Consider each situation below as it relates to the reaction in Model 1.
   a. Calculate the amount of reactants consumed and products made.
   b. Record the ratio of N_2 to H_2 to NH_3. Reduce the ratio to the lowest whole numbers possible.

	N_2 Consumed	**H_2 Consumed**	**NH_3 Produced**	**Ratio N_2:H_2:NH_3 (reduced)**
For a single reaction, how many molecules of each substance would be consumed or produced?				
If the reaction occurred one hundred times, how many molecules would be consumed or produced?				
If the reaction occurred 538 times, how many molecules would be consumed or produced?				

3. Refer to the data table in Question 2.
   a. How do the reduced ratios in the last column compare to the coefficients in the reaction shown in Model 1?
   b. Use mathematical concepts to explain how your answer in part *a* is possible.

4. Even 538 is a small number of molecules to use in a reaction. Typically chemists use much larger numbers of molecules. (Recall that one mole is equal to 6.02×10^{23} particles.) Consider each situation below as it relates to the reaction in Model 1: $N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$
   a. Calculate the amount of reactants consumed and products made.
   b. Record the ratio of N2 to H2 to NH3. Reduce the ratio to the lowest whole number possible.

	N_2 Consumed	**H_2 Consumed**	**NH_3 Produced**	**Ratio N_2:H_2:NH_3 (reduced)**
If the reaction occurred 6.02×10^{23} times, how many molecules would be consumed or produced?				
How many ***moles*** of each substance would be consumed or produced in the previous situation?				

5. Refer to the data table in Question 4.
   a. How do the reduced ratios in the last column compare to the coefficients in the reaction in Model 1?
   b. Use mathematical concepts to explain how your answer in part *a* is possible.

6. The ratio obtained from the coefficients in a balanced chemical equation is called the **mole ratio**.
   a. What is the mole ratio for the reaction in Model 1?
   b. Explain why this ratio is called the mole ratio?

7. Use the mole ratio from the balanced chemical equation in Model 1, $N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$, to solve the following problems. *Hint:* Set up proportions.
   a. How many moles of nitrogen would be needed to make 10.0 moles of ammonia?

   b. How many moles of ammonia could be made by completely reacting 9.00 moles of hydrogen?

   c. How many moles of hydrogen would be needed to react completely with 7.41 moles of nitrogen?

8. Consider this situation as it relates to the reaction in Model 1, $N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$.
   a. Calculate the amounts of reactants consumed and the amount of product made.
   b. Record the mass ratio of N2 to H2 to NH3. Reduce the ratio to the lowest whole numbers possible.

	N_2 Consumed	**H_2 Consumed**	**NH_3 Produced**	**Ratio N_2:H_2:NH_3 (reduced)**
How many grams of each substance would be consumed or produced in the situation in Question 4?				

9. Refer to the data table in Question 8.
   a. Can the mole ratio from a balanced chemical equation be interpreted as a ratio of masses?

   b. Use mathematical concepts to explain how your answer in part *a* is possible.

10. As a group, develop a plan to solve the following problem. Remember that the mole ratio cannot be used directly in this situation. *Note:* You do not need to do the actual calculation here.

"What mass of nitrogen is needed to produce 30.0 g of ammonia?"

Model 2 – Proposed Calculations for Mass of NH_3 to Mass of N_2

Toby's Method

$$\frac{\text{x grams}}{30.0\text{ g}} = \frac{1\text{ mole }N_2}{2\text{ moles }NH_3} \rightarrow \quad x = \_\_\_\_\_\_\text{ g }N_2$$

Rachel's Method

$$30.0\text{ g }NH_3 \times \frac{1\text{ mole }NH_3}{17.0\text{ g }NH_3} = \_\_\_\_\_\_\text{ moles }NH_3$$

$$\frac{\text{x mole }N_2}{\_\_\_\_\_\text{ mole }NH_3} = \frac{1\text{ mole }N_2}{2\text{ moles }NH_3} \rightarrow \quad x = \_\_\_\_\_\_\text{ moles }N_2$$

$$\_\_\_\_\_\_\text{ mole }N_2 \times \frac{28.0\text{ g }N_2}{1\text{ mole }N_2} = \_\_\_\_\_\_\text{ g }N_2$$

Jerry's Method

$$30.0\text{ g }NH_3 \times \frac{1\text{ mole }NH_3}{17.0\text{ g }NH_3} \times \frac{1\text{ mole }N_2}{2\text{ moles }NH_3} \times \frac{28.0\text{ g }N_2}{1\text{ mole }N_2} = \_\_\_\_\_\_\text{ g }N_2$$

11. Model 2 shows three proposed calculations to solve the problem in Question 10. Complete the calculations in Model 2 by filling in the underlined values.
12. Which method does not use the mole ratio in an appropriate manner? Explain.

13. Two of the methods in Model 2 give the same answer. Show that they are mathematically equivalent methods.

14. Use either Rachel or Jerry's method from Model 2 to calculate the mass of hydrogen needed to make 30.0 g of ammonia. N_2(g) + $3H_2$(g) à $2NH_3$(g).

Workbook Date:

Guiding Question:	
Do Now:	
Important Definitions and Equations:	**Notes:**
Response:	

21 Mole to Much!
Mole practice

1. **$2\ SO_2\ (g) + O_2\ (g) \rightarrow 2\ SO_3\ (g)$**
   - **a.** Write the molar ratios for O_2 to SO_3 and O_2 to SO_2.
   - **b.** How many moles of Oxygen gas are needed (with excess SO_2) to produce 10 moles of SO_3 gas?
   - **c.** How many grams of SO_3 will be produced from 2.5 moles of SO_2 in part B?
   - **d.** How many grams of oxygen gas are needed to exactly use up 2.5 grams of SO_2?

2. **$PCl_3\ (s) + Cl_2\ (g) \rightarrow PCl_5\ (s)$**
   - **a.** Write the molar ratios for PCl_3 to Cl_2 and PCl_3 to PCl_5.
   - **b.** How many moles of PCl_5 will be produced from 2.0 grams of PCl_3 (and excess chlorine gas)?
   - **c.** How many grams of PCl_5 can be produced from 10.0 grams of Cl_2 (and excess PCl_3).

3. $4\ NH_3\ (g) + 3\ O_2\ (g) \rightarrow 2\ N_2\ (g) + 6\ H_2O\ (g)$

a. Write the molar ratios for NH_3 to N_2 and H_2O to N_2.

b. How many grams of ammonia gas are needed (with excess O_2 gas) to make 0.5 moles of Nitrogen gas?

c. If 24 moles of water are produced when a sufficient amount of oxygen and ammonia, (NH_3), react, how many *liters* of nitrogen gas will be produced?