Unit 4 Chemical Reactions

Lesson 1 : What is a Chemical Reaction and How to Identify the Five Types of Reactions

Essential Question: How are chemical reactions classified? -What are the 5 types of chemical reactions?

Questions/ Vocab, etc.	Notes:

Chemical Equation

Shows the starting materials called _____ and the new substances formed called _____ of a chemical reaction.

Parts of a chemical equation

Reactants → Products

$$NaCl_{(aq)} + AgNO_{3(aq)} \rightarrow AgCl_{(s)} + NaNO_{3(aq)}$$

means
Solid (s)
Liquid (l)
Gas (g)
Aqueous (aq) dissolved in water

means
yields
to produce
to form

Translating a Word Equation into a Chemical Equation

Word equation: Magnesium metal is reacted with aqueous hydrochloric acid to produce aqueous magnesium chloride and hydrogen gas

Formula equation:

_____ + _____ → _____ + _____

Writing a chemical equation

→ You must write the correct chemical formulas or each reactant and product.

→ Common phrases such as "and", "is mixed with", "reacts with" are replaced with a + sign.

→ Phrases such as "yield", "produces", and "forms" are replaced with a →

→ Remember "BrINClHOF" to represent the 7 diatomic elements !

→ The formulas for the 7 are as follows:

Examples: Write a chemical equation for each

[1] Potassium metal is reacted with calcium bromide to form potassium bromide & calcium

[2] Copper (II) nitrate and sodium hydroxide react to form copper (II) hydroxide & sodium nitrate.

5 Types of Chemical Reactions *(WRITE IN THE EXAMPLES FROM THE NOTES)*

[1] Synthesis Reactions : when 2 or more substances combine to form a single SUBSTANCE

A + B → AB

Element + Element → Compound

[2] Decomposition Reactions: when 1 SUBSTANCE breaks apart into 2 or more substances; requires energy to initiate

AB → A + B

Compound → Element + Element

[3] Single Replacement Reaction: when a more reactive element replaces a less reactive element in a compound

BC + A → B + AC

Compound + Element → Element + Compound

[4] Double Replacement Reaction: when the positive ions of each aqueous compound replace each other

AB + CD → AD + CB

Compound + Compound → Compound + Compound

[5] Combustion:

Reaction of an element or compound with OXYGEN to form an oxide & heat

$A + O_2 \rightarrow AO + Heat$

Hydrocarbon reacts with OXYGEN to ***ALWAYS*** produce carbon dioxide, water & heat

$C_xH_y + O_2 \rightarrow CO_2 + H_2O + heat$

Lesson 2 : The Law of Conservation of Mass and How to Balance a Chemical Reaction

Essential Question: How do the Law of Conservation of Mass and chemical equations explain the interactions of atoms and molecules both conceptually and mathematically?

Questions/ Vocab, etc.	Notes:

Law of Conservation of Mass

→ Matter can neither be created nor destroyed, just changed in form.
- *Mass must stay constant through a change*

Mass of reactants = Mass of products

→ Must be the same number of atoms of each element on the left and right side of the equation.
→ To ensure that the numbers of each atom are the same, we must BALANCE the chemical equation.

How do we Begin Balancing an Equation

1. Start by counting the atoms of each substance

→ Subscripts tell you how many atoms of an element
→ Coefficients are small whole numbers placed in front of chemical formulas.
→ A coefficient is multiplied by the subscripts within each compound to determine total number of atoms of the element
→ A subscript outside of a parenthesis will multiply by all of the atoms inside the parenthesis
→ In the example above, there are 3 molecules of water; 6 hydrogen atoms & 3 oxygen atoms

SELF CHECK! Count the atoms in each compound.

a) $2(NH_4)_3PO_4$ N = _____ H =_____ P =_____ O =_____

b) $4\ KC_2H_3O_2$ K = _____ C = _____ H = _____ O = _____

c) $3\ Ca(NO_3)_2$ Ca= ___ N= ___ O= ___

2. Coefficients are added to change the number of atoms in a substance.

Example 1

____CH_4 + ____ O_2 → ____ CO_2 + ____ H_2O

3. When finished balancing, you can place a "1" in an empty coefficient location at the end of the process.

HINT: Chunk the polyatomic ions if they are on both sides of the equation.

OH^- is a polyatomic ion that is sometimes "hidden" in water. H_2O can be written like HOH

Example 2:

$$\_\_\_H_3PO_4 + \_\_\_\_Ca(OH)_2 \rightarrow \_\_\_Ca_3(PO_4)_2 + \_\_\_\_\_ HOH$$

Example 3:

$$\_\_\_\_\_ HCl + \_\_\_\_\_ Ca(OH)_2 \rightarrow \_\_\_\_\_ CaCl_2 + \_\_\_\_\_ H_2O$$

SELF CHECK!

a) $\_\_\_\_\_ Li + \_\_\_\_\_ H_2O \rightarrow \_\_\_\_\_ LiOH + \_\_\_\_\_ H_2$

b) $\_\_\_\_\_ Fe + \_\_\_\_\_ O_2 \rightarrow \_\_\_\_\_ Fe_2O_3$

Balancing Tips

1. Never start balancing by placing a 1 as a coefficient. Do it last.
2. Try to leave H & O for last when balancing.
3. Chunk polyatomic ions if present on both sides!
4. Change H_2O to H(OH) if the hydroxide ion(OH) is present on both sides.
5. If there are an odd number of 1 type of atom on one side and an even number of the same atom on the other side, make the odd number atoms equal by multiplying by 2.
6. Make sure the set of coefficients is in the simplest ratio.
7. When finished balancing, always re-check that all your atoms are equal on both sides!
8. In a combustion reaction, always start balancing with the C and H of the hydrocarbon. *If you fail at first, place a 2 in front of the first compound.*

Lesson 3 : Predicting Products of Synthesis and Decomposition Reactions & The Activity Series

Essential Question: What happens when chemicals react with one another?

Questions/ Vocab, etc.	Notes:

Steps to Predicting Products of the 5 Types of Chemical Reactions

1. Identify the type of reaction.
2. Use the reference sheet to determine which model to use.
3. Create the products following the model.
4. Don't forget to check the charges of any new ionic compound and format elements of BrINClHOF correctly.

Balance the chemical equation.**Synthesis & Decomposition Reactions**

1. Synthesis: 3 models

A. Formation of a Binary Compound: **This is the only one you need to know!**

What do you do? Bring symbols together (take no subscripts) & then check charges

A + B → AB

Metal + Nonmetal → Binary Ionic Compound

Example:

____K + ____ Br_2 →

SKIP TYPES B & C

2. Decomposition: 6 models

A. Binary Compound: **This is the only one you need to know!**

What do you do? Break binary compound into the 2 elements that make it up

** *Look for Diatomic Molecules* **

AB → A + B

Binary Ionic Compound → metal + nonmetal

Examples:

_____ $CaCl_2$ →

SKIP TYPES B - F

	Activity Series: chart that shows the reactivity of metals and halogens in a Single Replacement Reaction ✔ Elements on top of chart are more reactive than elements at the bottom ✔ More reactive elements can only replace less reactive elements ✔ Li can replace Ca ; Bi cannot replace Cr ✔ Special Rules: when a metal wants to replace H from water; need to look at print dealing with the temperature of the water ✔ There is an activity series chart for halogens as well. SELF CHECK: Determine if the reaction will take place using the activity series chart 1. $K + CaCl_2 \rightarrow$ 2. $Cu + Zn(OH)_2 \rightarrow$ 3. $Na + H_2O \rightarrow$ 4. $Ni + H_2O \rightarrow$ 5. $Mg + HCl \rightarrow$

Lesson 4 : Predicting Products of Single Replacement, Double Replacement and Combustion Reactions and the Use of Solubility Rules to Predict Precipitates

Essential Question: What happens when chemicals react with one another?

Questions/ Vocab, etc.	Notes:
	Single Replacement: 4 models ** Single Replacement Requires the Use of Activity Series [Rules Below]** Metal-Metal Replacement: What do you do? Is the single metal above the other metal in the Activity Series chart? **A + BC → AC + B** **Metal + ionic compound → new ionic compound + element** YES: Replace it & then check charges of new compound. Watch out for diatomic molecules formed. NO: Write NR $Li + K_2S \rightarrow Li_2S + K$ Element + compound → compound + element Examples: ____ Zn + _____ $Cu(NO_3)_2 \rightarrow$

B. Active metal replacing Hydrogen from Water :

What to do? Is the single element above the H in the activity series chart?

- Look at specific rules!
- Can change H_2O to HOH

YES: Replace it & then check charges of new metal hydroxide and then add hydrogen gas (diatomic)

NO: Write NR

M + H_2O → MOH + H_2

Element + water → base + element

Examples:

1. ____ Na + ___ $H_2O_{(l)}$ →

2. ___ Al + ___ $H_2O_{(l)}$ →

3. ___ Al + ___ $H_2O_{(g)}$ →

Active metal replacing Hydrogen from an Acid:

What to do? Is the single element above the H in the activity series chart?

- Look at specific rules!

YES: Replace it & then check charges of new compound and then add hydrogen gas (diatomic)

NO: Write NR

M + HX → MX + H_2

Element + acid → compound + element

Examples:

___ Mg + ___ HCl →

Halide-Halide Replacement:

What to do? Is the single halogen above the other halogen in the activity series chart?

YES: Replace it & then check charges of new compound. Watch out for diatomic molecules!

NO: Write NR

D + BC → BD + C

halogen + compound → compound + halogen

Examples:

[1] _____ Cl_2 + _____ KBr →

[2] _____ I_2 + _____ NaCl →

Solubility Rules Chart: Used to Classify substances as soluble & insoluble.

√ Found on your Reference Sheet

- ✔ Categorized by anion
- ✔ Soluble: substance will dissolve in water
- ✔ Insoluble: substance will not dissolve in water. Also known as a precipitate when the insoluble substance is formed on the product side. (PP)

SELF CHECK! Determine if the following substances are soluble (S) or insoluble (I)

1. $CaCl_2$ _____
2. K_3PO_4 _____
3. $MgCO_3$ _____
4. $Zn(OH)_2$ _____
5. $NiSO_4$ _____
6. $AgNO_3$ _____

4. Double Replacement: 2 models

AB + CD → CB + AD

Compound + Compound → Compound + Compound

A. Formation of a Precipitate:

What to do? Swap positive ions & then check charges on the newly formed compounds.

- Use the solubility rules chart to identify if there is a precipitate (INSOLUBLE SOLID) on the product side!

AB + CD → CB + AD

compound + compound → compound + compound

Examples:

___ NaCl + ____ $AgNO_3$ →

B. Acid –Base Neutralization Reaction:

What to do? Swap positive ions & then check charges on new compounds.

HX + MOH → MX + H_2O

Acid + Base → ionic comp + water

Examples:

___ KOH + ___ H_2SO_4 →

5. Combustion: 1 model

A. Burning of a Hydrocarbon:

What to do? Products are always carbon dioxide and water.

Hydrocarbon + O_2 → CO_2 + H_2O

Examples:

1. ___ C_3H_8 + ___ O_2 →

2. ____ CH_3OH + ____ O_2 →

Lesson 5 : Writing Net Ionic Reactions

Essential Question: How is the phenomenon of precipitate formation explained on the atomic level?

Questions/ Vocab, etc.

NET IONICS of Precipitation Reactions

Writing Net Ionic Equations

To show the details of aqueous reactions that involve ions in aqueous solutions, we use ionic equations.

- A MOLECULAR Equation: the typical chemical equation you are used to writing, keeping all molecules together
- A COMPLETE IONIC Equation: shows all the particles in a solution as they really exist, as ions or molecules.

- Anything aqueous needs to be split apart into cations & anions.
- Any solid substance should stay intact.
- Coefficients need to be multiplied by subscripts to determine the exact amount of cations and anions

- A SPECTATOR Ion: an ion that is not participating in the reaction; you can identify it because it is found on both the reactant and product side of an equation in the same amounts.
- A NET IONIC Equation: the final equation showing the major players. All spectator ions are removed.

Examples:

1. Molecular Equation: $KI_{(aq)} + AgNO_{3(aq)} \rightarrow KNO_{3(aq)} + AgI_{(s)}$

Complete Ionic:

Net Ionic:

2. Molecular Equation: $2NaOH_{(aq)} + CuCl_{2(aq)} \rightarrow 2NaCl_{(aq)} + Cu(OH)_{2(s)}$

Complete Ionic:

Net Ionic:

3. Molecular Equation: $FeCl_{3(aq)} + 3NaOH_{(aq)} \rightarrow Fe(OH)_{3(S)} + 3NaCl_{(aq)}$

Complete Ionic:

Net Ionic: