| $\mathrm{D}^{121} / \mathrm{R}^{\text {a }}$ |  | ${ }^{11}$ |  | $\mathbf{S}^{\prime \prime} \mathrm{H}$ |  | A |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |

Regents Chemistry: Dr. Shanzer

## Practice Packet

Chapter 7: Formulas \& Chemical Equations



| How many atoms are in a formula? |  |  |
| :--- | :--- | :--- |
| $\mathrm{CH}_{3} \mathrm{COOH} \rightarrow \mathrm{C}=2 \quad \mathrm{H}=4 \quad \mathrm{O}=2 \quad \rightarrow 8$ |  |  |
| $\mathrm{Mg}\left(\mathrm{NO}_{3}\right)_{2} \rightarrow \mathrm{Mg}=1$ | $\mathrm{~N}=2 \quad \mathrm{O}=6$ | $\rightarrow 9$ |
|  |  |  |
|  |  |  |



## Objective:

How do we determine if a substance is ionic and write it's name or formula?


Polyatomic ion $\rightarrow$ 2-3 nonmetals bonded together that have a charge. These are ions, NOT compounds!!

| Table E <br> Selected Polyatomic lons |  |  |  | What you see is what you get |
| :---: | :---: | :---: | :---: | :---: |
| $\mathrm{H}_{3} \mathrm{O}^{-}$ | hydronium | $\mathrm{COO}_{4}{ }^{2}$ | chromate |  |
| $\mathrm{Hg}_{\mathrm{g}}{ }^{\text {a }}$ | dimersury (1) | $\mathrm{Cr}_{2} \mathrm{O}_{7}^{2}$ | dichromate |  |
| $\mathrm{NH}_{4}{ }^{\text {- }}$ | annmoaium | $\mathrm{MrO}_{4}^{-}$ | permanganate |  |
|  | soctate | $\mathrm{NO}_{2}{ }^{-}$ | nitrite |  |
| $\mathrm{CH}_{3} \mathrm{COO}{ }^{-}$ |  | $\mathrm{NO}_{3}{ }^{-}$ | nitrate |  |
| $\frac{\mathrm{CN}}{} \mathrm{CO}^{2}$ | cyanide | $\mathrm{O}_{2}{ }^{2}$ | peroside |  |
| C- ${ }^{\text {CO, }}$ | carbonate | OH- | hydroxide |  |
| $\mathrm{HCO}_{5}$ | hydrogen carbonate | $\mathrm{PO}_{4}{ }^{3}$ | phoophate |  |
| $\mathrm{C}_{2} \mathrm{O}_{4}{ }^{2}$ | orabate | SCN- | thioganate |  |
| $\mathrm{ClO}^{-}$ | hypochlorite | $\mathrm{SO}_{3}{ }^{2}$ | sulfite |  |
| $\mathrm{CHO}_{2}{ }^{-}$ | chlorite | $\mathrm{SO}_{4}{ }^{2}$ | sulfate |  |
| $\mathrm{ClO}_{3}^{-}$ | chlorate | $\mathrm{HSO}_{4}^{-}$ | hydrogen sulfate |  |
| $\mathrm{ClO}_{4}^{-}$ | perchlorate | $\mathrm{S}_{2} \mathrm{O}_{3}{ }^{2-}$ | thiosulfate |  |

## Writing an ionic formula from a name

1. Use the periodic table and/or table E to locate the charges for the ions after you have determined the compound is ionic. For nonmetals, select the first charge.
2. Write the symbol for each ion, using subscripts when needed, to create the lowest ratio that makes the sum of the charges equal to zero. (+) ion first, (-) ion second.
${ }^{* *}$ Remember that many polyatomic ions have subscripts as part of their formula and this is not used as a subscript for creating the ratio that equals zero**

## Writing a name from an ionic formula

1. If the $(+)$ ion is a metal, it keeps the same name.
2. If the (-) ion is an element, drop the last few letters and change the ending to "ide".
** If it is a polyatomic ion, then use the name EXACTLY as it appears on Table E **
$\mathrm{NaBr} \rightarrow$ Sodium Bromide
$\mathrm{Al}_{2}\left(\mathrm{SO}_{4}\right)_{3} \rightarrow$ Aluminum Sulfate
$\left(\mathrm{NH}_{4}\right)_{3} \mathrm{PO}_{4} \rightarrow$ Ammonium Phosphate


## Formula Writing and Naming Stock Ionic Substances

Video 7.2

## Objective:

How do we write the name or formula for an ionic substance whose metal has more than one charge?

- The rules are the same as the previous video except for one change. When the metal is located in groups 3-12, it may have multiple charges. Polyatomic ions are still from Table E.



## Writing an stock ionic formula from a name

1. Use the periodic table and/or table E to locate the charges for the ions after you have determined the compound is ionic.
For nonmetals, select the first charge.
2. If the metal has more than one charge, there will be a roman numeral in the name indicating the exact charge of the metal. It DOES NOT mean the $1^{\text {st }}, 2^{\text {nd }}, 3^{\text {rd }}$ charge, it is the actual charge.


## Writing a name from a stock ionic formula

1. If the $(+)$ ion is a metal, it keeps the same name..
2. Determine the charge of the metal ion by using the negative charges to get a sum equal to 0 . The metal's charge will be indicated in the name by using a roman numeral
3. If the (-) ion is an element, drop the last few letters and change the ending to "ide".
** If it is a polyatomic ion, then use the name EXACTLY as it appears on Table E **

## Formula Writing and Naming Molecules

Video 7.3
. -
3. Write the symbol for each ion, using subscripts when needed, to create the lowest ratio that makes the sum of the charges equal to zero. (+) ion first, (-) ion second
${ }^{* *}$ Remember that many polyatomic ions have subscripts as part of their formula and this is not used as a subscript for creating the ratio that equals zero**
$\left.+2 \begin{array}{l}-1 \\ -1\end{array}\right\}=0$
Iron (II) Chloride $\rightarrow \mathrm{FeCl}_{2} \quad 1$ to 2 ratio
$\left.\begin{array}{ll} & -2 \\ +3 & -2 \\ +3 & -2\end{array}\right\}=0$

Nickel (III) Sulfide $\rightarrow \mathrm{Ni}_{2} \mathrm{~S}_{3} \quad 2$ to 3 ratio

$$
\begin{aligned}
& \begin{array}{l}
-1 \\
-1 \\
-1 \\
-1
\end{array}=0 \\
& \mathrm{MnBr}_{4} \rightarrow \text { Manganese (IV) Bromide } \\
& \left.\begin{array}{ll}
+3 & -2 \\
+2 \\
+3 & -2 \\
-2
\end{array}\right\} \\
& \stackrel{+3}{\mathrm{Cr}_{2}}\left(\mathrm{SO}_{4}\right)_{3} \rightarrow \text { Chromium (III) Sulfate }
\end{aligned}
$$

## Objective:

How do we write the name or formula for a molecular substance?

## Molecular Substances

- AKA - molecules or covalent compounds
- Molecular substances are composed of 2 non-metals only!


## Covalent Compounds

- Because of the way non-metals bond together to form compounds the charge does not play a role in the name or subscript
- The number of each atom is given by prefixes nonmetals can combine with each other in many different combinations.

| number of atoms | prefix |  | xample |
| :---: | :---: | :---: | :---: |
| 1 | mono | NO | nitrogen monoxide |
| 2 | di | $\mathrm{NO}_{2}$ | nitrogen dioxide |
| 3 | tri | $\mathrm{N}_{2} \mathrm{O}_{3}$ | dinitrogen trioxide |
| 4 | tetra | $\mathrm{N}_{2} \mathrm{O}_{4}$ | dinitrogen tetraoxide |
| 5 | penta | $\mathrm{N}_{2} \mathrm{O}_{5}$ | dinitrogen pentaoxide |
| 6 | hexa |  | sulphur hexa fluoride |
| 7 | hepta | if, | iodine hepta fluoride |
| 8 | octa | $\mathrm{P}_{4} \mathrm{O}_{8}$ | tetra phosphur decoxide |
| 9 | nona | $\mathrm{P}_{4} 5_{9}$ | tetra phusphur nona sulphide |
| 10 | deca | $\mathrm{AS}_{4} \mathrm{O}_{10}$ | tetra arsinic decoxide |

*The prefix "mono" is never used for the first element *The second element always gets s prefix $\star$ The ending of the second element becomes -ide


## Covalent Compounds

|  | Mono- | 1 |
| :---: | :--- | :--- |
| The number | Di- | 2 |
| of each atom | Tetra- | 3 |
| is given by | Penta- | 5 |
| prefixes | Hexa- | 6 |
|  | Hepta- | 7 |
|  | Octa- | 8 |
|  | Nona- | 9 |
|  | Deca- | 10 |


| Writing Molecular |  |
| :---: | :---: |
| Formulas |  |
| Sulfur hexachloride | $\mathrm{SCl}_{6}$ |
| Carbon tetrachloride | $\mathrm{CCl}_{4}$ |
| Dinitrogen tetraoxide | $\mathrm{N}_{2} \mathrm{O}_{4}$ |
|  |  |

[^0]Sketch Notes

Sketch Notes

Video 7.1
Create formulas for the following ionic compounds.

| IUPAC NAME | FORMULA |
| :---: | :---: |
| Calcium chloride |  |
| Magnesium iodide |  |
| Ammonium Bromide |  |
| Barium phosphate |  |
| Potassium phosphide |  |
| Lithium nitrite |  |
| Aluminum chloride |  |
| Zinc iodide |  |
| Zinc sulfide |  |
| Magnesium nitride |  |
| Ammonium sulfite |  |
| Magnesium hydroxide |  |

Name the following ionic compounds.

| FORMULA | IUPAC NAME |
| :---: | :---: |
| $\mathrm{K}_{2} \mathrm{CO}_{3}$ |  |
| $\mathrm{ZnI}_{2}$ |  |
| $\mathrm{Mg}_{3}\left(\mathrm{PO}_{4}\right)_{2}$ |  |
| $\mathrm{NH}_{4} \mathrm{I}$ |  |
| $\mathrm{Al}_{2} \mathrm{O}_{3}$ |  |
| $\mathrm{Ag}_{2} \mathrm{SO}_{3}$ |  |
| $\mathrm{Mg}_{3} \mathrm{P}_{2}$ |  |
| $\mathrm{Be}(\mathrm{OH})_{2}$ |  |
| SrS |  |
| $\mathrm{Al}_{2} \mathrm{~S}_{3}$ |  |
| $\mathrm{MgCl}_{2}$ |  |
| $\mathrm{Ba}(\mathrm{OH})_{2}$ |  |

Stock System for Ionic Substances
Video 7.2
Create Formulas for the following Ionic substances.

| IUPAC NAME | FORMULA |
| :---: | :--- |
| Copper (II) oxide |  |
| Chromium (III) chloride |  |
| Lead (II) nitride |  |
| Copper (I) sulfate |  |
| Chromium (III) nitrite |  |
| Manganese (IV) sulfide |  |
| Lead (II) phosphide |  |
| Nickel (III) oxide |  |
| Gold (III) nitrate |  |
| copper (II) sulfite |  |
| Lead (IV) sulfide |  |
| Titanium (IV) nitride |  |

Name the following Ionic substances.

| FORMULA | IUPAC NAME |
| :---: | :---: |
| $\mathrm{CrF}_{2}$ |  |
| $\mathrm{Cu}_{2} \mathrm{~S}$ |  |
| $\mathrm{FePO}_{4}$ |  |
| $\mathrm{Co}_{3} \mathrm{~N}_{2}$ |  |
| $\mathrm{Mn}\left(\mathrm{NO}_{2}\right)_{3}$ |  |
| PbO |  |
| $\mathrm{TiI} \mathrm{Cl}_{4}$ |  |
| $\mathrm{CoCO}_{3}$ |  |
| $\mathrm{Sn}_{3}\left(\mathrm{PO}_{4}\right)_{2}$ |  |
| $\mathrm{CuCl}_{2}$ |  |
| $\mathrm{Ni}_{3} \mathrm{P}_{2}$ |  |
| $\mathrm{Fe}_{3} \mathrm{~N}_{2}$ |  |

Molecular Compounds
Video 7.3
Create formulas for the following Molecular substances

| IUPAC NAME | FORMULA |
| :---: | :---: |
| Carbon dioxide |  |
| Carbon monoxide |  |
| Diphosphorus pentoxide |  |
| Dinitrogen monoxide |  |
| Silicon dioxide |  |
| Carbon tetrabromide |  |
| Sulfur dioxide |  |
| Phosphorus pentabromide |  |
| Iodine trichloride |  |
| Nitrogen triiodide |  |
| Dinitrogen trioxide |  |

Name the following Molecular Substances

| FORMULA | IUPAC NAME |
| :---: | :---: |
| $\mathrm{N}_{2} \mathrm{O}_{4}$ |  |
| $\mathrm{SO}_{3}$ |  |
| NO |  |
| $\mathrm{NO}_{2}$ |  |
| $\mathrm{PCl}_{3}$ |  |
| $\mathrm{CCl}_{4}$ |  |
| $\mathrm{H}_{2} \mathrm{O}$ |  |
| $\mathrm{SeF}_{6}$ |  |
| $\mathrm{As}_{2} \mathrm{O}_{5}$ |  |

## Compounds: Putting it all Together

Name: $\qquad$

The compounds below are of several different types. Use the flow chart to determine the naming system to use and name each compound show below.

| Formula | IUPAC Name |
| :--- | :--- |
| 1. $\mathrm{Fe}\left(\mathrm{NO}_{2}\right)_{3}$ |  |
| 2. $\mathrm{Na}_{2} \mathrm{~S}_{2} \mathrm{O}_{3}$ |  |
| 3. $\mathrm{P}_{2} \mathrm{O}_{5}$ |  |
| 4. $\mathrm{BaBr}_{2}$ |  |
| 5. $\mathrm{Mn}_{2}\left(\mathrm{Cr}_{2} \mathrm{O}_{7}\right)_{7}$ |  |
| 6. $\mathrm{CaCl}_{2}$ |  |
| 7. $\left(\mathrm{NH}_{4}\right)_{2} \mathrm{~S}$ |  |
| 8. $\mathrm{CuF}^{2}$ |  |
| 9. $\mathrm{Br}_{2} \mathrm{O}$ |  |
| 10. $\mathrm{HgSO}_{4}$ |  |
| 11. $\mathrm{Al}_{2} \mathrm{O}_{3}$ |  |
| 12. $\mathrm{SCl}_{6}$ |  |
| 13. $\mathrm{IF}_{7}$ |  |
| 14. $\mathrm{Cr}_{7}\left(\mathrm{CO}_{3}\right)_{3}$ |  |
| 15. $\mathrm{KNO}_{2}$ |  |

Write the correct name for the chemical formulas below. Use the flow chart to help!

| IUPAC Name | Formula |
| :--- | :--- |
| 1. antimony tribromide |  |
| 2. chlorine dioxide |  |
| 3. sodium sulfate |  |
| 4. iron (II) oxide |  |
| 5. calcium chloride |  |
| 6. ammonia |  |
| 7. zinc hydroxide |  |
| 8. diphosphorus pentoxide |  |
| 9. zinc nitrate |  |
| 10. iron (III) oxide |  |
| 11. potassium nitride |  |
| 12. tin (IV) oxide |  |
| 13. ammonium phosphate |  |
| 14. magnesium hydroxide |  |
| 15. carbon monoxide |  |

1. In the formula $X_{2}\left(\mathrm{SO}_{4}\right)_{3}$, the $X$ represents a metal. This metal could be located on the Periodic Table in
1) Group 1
2) Group 13
3) Group 2
4) Group 14
2. Every water molecule has two hydrogen atoms bonded to one oxygen atom. This fact supports the concept that elements in a compound are
1) chemically combined in a fixed proportion
2) chemically combined in proportions that vary
3) physically mixed in a fixed proportion
4) physically mixed in proportions that vary
3. Which element forms a compound with chlorine with the general formula MCl
1) $R b$
2) Ra
3) Re
4) $R n$
4. Which formula represents strontium phosphate?
1) $\mathrm{SrPO}_{4}$
2) $\mathrm{Sr}_{3} \mathrm{PO}_{8}$
3) $\mathrm{Sr}_{2}\left(\mathrm{PO}_{4}\right)_{3}$
4) $\mathrm{Sr}_{3}\left(\mathrm{PO}_{4}\right)_{2}$
5. The compound $X C$ is classified as ionic if $X$ represents the element
1) H
2) 1
3) $R b$
4) Br
6. What is the chemical formula for iron(III) oxide?
1) FeO
2) $\mathrm{Fe}_{2} \mathrm{O}_{3}$
3) $\mathrm{Fe}_{3} \mathrm{O}$
4) $\mathrm{Fe}_{3} \mathrm{O}_{2}$
7. In which compound is the ratio of metal ions to nonmetal ions 1 to 2 ?
1) calcium bromide
2) calcium phosphide
3) calcium oxide
4) calcium sulfide
8. Element $X$ reacts with iron to form two different compounds with the formulas $\mathrm{Fe} X$ and $\mathrm{Fe}_{2} X_{3}$. To which group on the Periodic Table does element $X$ belong?
1) Group 8
2) Group 13
3) Group 2
4) Group 16
9. What is the chemical formula for sodium sulfate?
1) $\mathrm{Na}_{2} \mathrm{SO}_{3}$
2) $\mathrm{Na}_{2} \mathrm{SO}_{4}$
3) $\mathrm{NaSO}_{3}$
4) $\mathrm{NaSO}_{4}$
10. What is the IUPAC name for the compound ZnO ?
1) zinc oxide
2) zinc peroxide
3) zinc oxalate
4) zinc hydroxide
11. What is the chemical formula of iron(III) sulfide?
1) FeS
2) $\mathrm{Fe}_{2} \mathrm{~S}_{3}$
3) $\mathrm{FeSO}_{3}$
4) $\mathrm{Fe}_{2}\left(\mathrm{SO}_{3}\right)_{3}$
12. Which formula represents copper(I) oxide?
1) CuO
2) $\mathrm{CuO}_{2}$
3) $\mathrm{Cu}_{2} \mathrm{O}$
4) $\mathrm{Cu}_{2} \mathrm{O}_{2}$
13. Which formula represents lead(II) chromate?
1) $\mathrm{PbCrO}_{4}$
2) $\mathrm{Pb}\left(\mathrm{CrO}_{4}\right)_{2}$
3) $\mathrm{Pb}_{2} \mathrm{CrO}_{4}$
4) $\mathrm{Pb}_{2}\left(\mathrm{CrO}_{4}\right)_{3}$
14. A compound is made up of iron and oxygen, only.

- The ratio of iron ions to oxide ions is 2:3 in this compound. The IUPAC name for this compound is

1) triiron dioxide
2) iron(III) oxide
3) iron(II) oxide
4) iron trioxide
15. What is the IUPAC name for the compound FeS?
1) iron(II) sulfate
2) iron(II) sulfide
3) iron(III) sulfate
4) Iron(III) sulfide
16. What is the formula of titanium(II) oxide?
1) TiO
2) $\mathrm{TiO}_{2}$
3) $\mathrm{Ti}_{2} \mathrm{O}$
4) $\mathrm{Ti}_{2} \mathrm{O}_{3}$
17. Which is a binary compound?
1) $\mathrm{CaCl}_{2}$
2) KOH
3) $\mathrm{NaNO}_{3}$
4) $\mathrm{MgSO}_{4}$
18. What is the correct formula for ammonium carbonate?
1) $\mathrm{NH}_{4}\left(\mathrm{CO}_{3}\right)_{2}$
2) $\mathrm{NH}_{4} \mathrm{CO}_{3}$
3) $\left(\mathrm{NH}_{4}\right)_{2}\left(\mathrm{CO}_{3}\right)_{2}$
4) $\left(\mathrm{NH}_{4}\right)_{2} \mathrm{CO}_{3}$

## NUMBER OF ATOMS IN A FORMULA Name

$\qquad$

Determine the number of atoms in the following chemical formulas.

1. NaCl

2. $\mathrm{H}_{2} \mathrm{SO}_{4}$ $\qquad$
3. $\mathrm{KNO}_{3}$ $\qquad$
4. $\mathrm{CaCl}_{2}$ $\qquad$
5. $\mathrm{C}_{2} \mathrm{H}_{6}$

6. $\mathrm{Ba}(\mathrm{OH})_{2}$ $\qquad$
7. $\mathrm{NH}_{4} \mathrm{Br}$

8. $\mathrm{Ca}_{3}\left(\mathrm{PO}_{4}\right)_{2}$ $\qquad$
9. $\mathrm{Al}_{2}\left(\mathrm{SO}_{4}\right)_{3}$ $\qquad$
10. $\mathrm{Mg}\left(\mathrm{NO}_{3}\right)_{2}$ $\qquad$ 20. $\mathrm{K}_{2} \mathrm{SO}_{3}$

TRY THESE Classify each of the following reactions.

$$
\begin{aligned}
& \mathrm{PbCl}_{2}+\mathrm{AgNO}_{3} \rightarrow \mathrm{~Pb}\left(\mathrm{NO}_{3}\right)_{2}+\mathrm{AgCl} \\
& \mathrm{NH}_{3}+\mathrm{HCl} \rightarrow \mathrm{NH}_{4} \mathrm{Cl} \\
& \mathrm{AlCl}_{3}+\mathrm{Na}_{2} \mathrm{SO}_{4} \rightarrow \mathrm{Al}_{2}\left(\mathrm{SO}_{4}\right)_{3}+\mathrm{NaCl} \\
& \mathrm{Zn}+\mathrm{S} \rightarrow \mathrm{ZnS} \\
& \mathrm{Al}_{2}\left(\mathrm{SO}_{4}\right)_{3}+\mathrm{BaCl}_{2} \rightarrow \mathrm{BaSO}_{4}+\mathrm{AlCl}_{3} \\
& \mathrm{Al}_{2} \mathrm{~S}_{3} \rightarrow \mathrm{Al}+\mathrm{S} \\
& \mathrm{H}_{2} \mathrm{SO}_{4}+\mathrm{Fe} \rightarrow \mathrm{H}_{2}+\mathrm{FeSO}_{4} \\
& \mathrm{C}_{12} \mathrm{H}_{22} \mathrm{O}_{11}+\mathrm{O}_{2} \rightarrow \mathrm{CO}_{2}+\mathrm{H}_{2} \mathrm{O} \\
& \mathrm{Mg}(\mathrm{OH})_{2}+\mathrm{H}_{2} \mathrm{SO}_{4} \rightarrow \mathrm{MgSO}_{4}+\mathrm{H}_{2} \mathrm{O} \\
& \mathrm{NaOH}+\mathrm{CuSO}_{4} \rightarrow \mathrm{Na}_{2} \mathrm{SO}_{4}+\mathrm{Cu}(\mathrm{OH})_{2} \\
& \mathrm{C}_{4} \mathrm{H}_{12}+\mathrm{O}_{2} \rightarrow \mathrm{H}_{2} \mathrm{O}+\mathrm{CO}_{2} \\
& \mathrm{Fe}+\mathrm{O}_{2} \rightarrow \mathrm{Fe}_{2} \mathrm{O}_{3} \\
& \mathrm{Mg}_{3}\left(\mathrm{PO}_{4}\right)_{2}+\mathrm{H}_{2} \rightarrow \mathrm{Mg}+\mathrm{H}_{3} \mathrm{PO}_{4} \\
& \mathrm{NH}_{4} \mathrm{NO}_{3} \rightarrow \mathrm{~N}_{2} \mathrm{O}+\mathrm{H}_{2} \mathrm{O} \\
& \mathrm{H}_{2} \mathrm{O}+\mathrm{Na} \rightarrow \mathrm{NaOH}+\mathrm{H}_{2}
\end{aligned}
$$

$\qquad$

## Balancing Chemical Equations

We balance chemical equations to confirm the law of conservation of mass. The law of conservation of mass states that the mass of substances produced by a chemical reaction is always equal to the mass of the reactants. Matter is neither created nor destroyed.

## RULES FOR BALANCING CHEMICAL EQUATIONS:

1. All formulas for molecules and compounds must be correct (No cheating!)
2. Add coefficients to balance atoms.
3. ONLY change coefficients, NOT formulas or subscripts
4. Balance the atoms in the largest compound first
5. Balance monatomic and diatomic elements last
6. Check to be sure that the number of atoms are the same on both sides of the equation
7. Reduce all coefficients to the lowest whole number ratio

## Balance the following chemical equations.

1. $\qquad$ $\mathrm{Ca}+$ $\qquad$ $\mathrm{O}_{2} \rightarrow$ $\qquad$ CaO
2. $\qquad$ $M g+$ $\qquad$ $\mathrm{HCl} \rightarrow$ $\qquad$ $\mathrm{H}_{2}+$ $\qquad$ $\mathrm{MgCl}_{2}$
3. $\qquad$ $\mathrm{AgNO}_{3}+$ $\qquad$ $\mathrm{Na}_{2} \mathrm{~S} \rightarrow$ $\qquad$ $\mathrm{Ag}_{2} \mathrm{~S}+$ $\qquad$ $\mathrm{NaNO}_{3}$
4. $\qquad$ $\mathrm{HCl}+$ $\qquad$ $\mathrm{Fe}_{2} \mathrm{O}_{3} \rightarrow$ $\qquad$ $\mathrm{H}_{2} \mathrm{O}+$ $\qquad$ $\mathrm{FeCl}_{3}$
5. $\qquad$ $\mathrm{AlBr}_{3}+$ $\qquad$ $\mathrm{K}_{2} \mathrm{SO}$ $\qquad$ $\mathrm{KBr}+$ $\qquad$ $\mathrm{Al}_{2}\left(\mathrm{SO}_{4}\right)_{3}$
6. $\quad$ _ $\mathrm{S}+\ldots \mathrm{O}_{2} \rightarrow \quad \mathrm{SO}_{3}$
7. $\quad \mathrm{Zn}+\ldots \ldots \mathrm{ZnCl}_{2}+\ldots \mathrm{H}_{2}$
8. $\quad \mathrm{Na}+\ldots \mathrm{Cl}_{2} \rightarrow \ldots \quad \mathrm{NaCl}$
9. $\quad \mathrm{Al}_{2} \mathrm{O}_{3} \rightarrow \ldots \quad \mathrm{Al}+\ldots \mathrm{O}_{2}$
10.___ $\mathrm{LiBr}+\ldots \mathrm{F}_{2} \rightarrow \ldots \mathrm{Br}_{2}+\ldots \quad \mathrm{LiF}$

## Balancing Equations

Balance the following chemical equations.

4. $\quad \mathrm{SnO}_{2}+\ldots \mathrm{H}_{2} \longrightarrow \quad \mathrm{Sn} \quad+\ldots \mathrm{H}_{2} \mathrm{O}$
5. $\quad \mathrm{NH}_{3}+\ldots \mathrm{O}_{2} \longrightarrow \longrightarrow \quad \mathrm{NO} \quad+\ldots \mathrm{H}_{2} \mathrm{O}$
6. $\quad \mathrm{KNO}_{3}+\ldots \mathrm{H}_{2} \mathrm{CO}_{3} \longrightarrow \longrightarrow \quad \mathrm{~K}_{2} \mathrm{CO}_{3}+\ldots \quad \mathrm{HNO}_{3}$
7. $\longrightarrow \mathrm{B}_{2} \mathrm{Br}_{6}+\ldots \mathrm{HNO}_{3} \longrightarrow \longrightarrow \mathrm{~B}\left(\mathrm{NO}_{3}\right)_{3}+\ldots \mathrm{HBr}$
8. $\longrightarrow \mathrm{BF}_{3}+\ldots \mathrm{Li}_{2} \mathrm{SO}_{3} \longrightarrow \longrightarrow \mathrm{~B}_{2}\left(\mathrm{SO}_{3}\right)_{3}+\ldots \quad \mathrm{LiF}$
9. $\quad\left(\mathrm{NH}_{4}\right)_{3} \mathrm{PO}_{4}+\ldots \quad \mathrm{Pb}\left(\mathrm{NO}_{3}\right)_{4} \longrightarrow \longrightarrow \mathrm{~Pb}_{3}\left(\mathrm{PO}_{4}\right)_{4}+\ldots \mathrm{NH}_{4} \mathrm{NO}_{3}$
10. $\longrightarrow \mathrm{SeCl}_{6}+\ldots \mathrm{O}_{2} \longrightarrow \longrightarrow \mathrm{SeO}_{2}+\ldots \mathrm{Cl}_{2}$

## Types of Chemical Reactions

Do atoms rearrange in predictable patterns during chemical reactions?

## Why?

Recognizing patterns allows us to predict future behavior. Weather experts use patterns to predict dangerous storms so people can get their families to safety. Political analysts use patterns to predict election outcomes. Similarly, chemists classify chemical equations according to their patterns to help predict products of unknown but similar chemical reactions.

## Model 1 - Types of Reactions

## Set A

$4 \mathrm{Fe}(\mathrm{s})+3 \mathrm{O}_{2}(\mathrm{~g}) \rightarrow 2 \mathrm{Fe}_{2} \mathrm{O}_{3}(\mathrm{~s})$
$\mathrm{N}_{2}(\mathrm{~g})+3 \mathrm{H}_{2}(\mathrm{~g}) \rightarrow 2 \mathrm{NH}_{3}(\mathrm{~g})$
$2 \mathrm{SO}_{2}(\mathrm{~g})+\mathrm{O}_{2}(\mathrm{~g}) \rightarrow 2 \mathrm{SO}_{3}(\mathrm{~g})$
$\mathrm{MgO}(\mathrm{s})+\mathrm{H}_{2} \mathrm{O}(\mathrm{l}) \rightarrow \mathrm{Mg}(\mathrm{OH})_{2}(\mathrm{aq})$
$\mathrm{P}_{2} \mathrm{O}_{5}(\mathrm{~g})+3 \mathrm{H}_{2} \mathrm{O}(\mathrm{l}) \rightarrow 2 \mathrm{H}_{3} \mathrm{PO}_{4}(\mathrm{aq})$
$\mathrm{SO}_{3}(\mathrm{~g})+\mathrm{H}_{2} \mathrm{O}(\mathrm{l}) \rightarrow \mathrm{H}_{2} \mathrm{SO}_{4}(\mathrm{aq})$
Set C
$2 \mathrm{FeCl}_{3}(\mathrm{aq})+3 \mathrm{Zn}(\mathrm{s}) \rightarrow 2 \mathrm{Fe}(\mathrm{s})+3 \mathrm{ZnCl}_{2}(\mathrm{aq})$
$2 \mathrm{Al}\left(\mathrm{NO}_{3}\right)_{3}(\mathrm{aq})+3 \mathrm{Ca}(\mathrm{s}) \rightarrow 3 \mathrm{Ca}\left(\mathrm{NO}_{3}\right)_{2}(\mathrm{aq})+2 \mathrm{Al}(\mathrm{s})$
$\mathrm{Mg}(\mathrm{s})+\mathrm{CuSO}_{4}(\mathrm{aq}) \rightarrow \mathrm{MgSO}_{4}(\mathrm{aq})+\mathrm{Cu}(\mathrm{s})$
$2 \mathrm{Al}(\mathrm{s})+6 \mathrm{HCl}(\mathrm{aq}) \rightarrow 2 \mathrm{AlCl}_{3}(\mathrm{aq})+3 \mathrm{H}_{2}(\mathrm{~g})$
$\mathrm{Cl}_{2}(\mathrm{~g})+2 \mathrm{NaBr}(\mathrm{aq}) \rightarrow 2 \mathrm{NaCl}(\mathrm{aq})+\mathrm{Br}_{2}(\mathrm{l})$
$\mathrm{ZnBr}_{2}(\mathrm{aq})+\mathrm{F}_{2}(\mathrm{~g}) \rightarrow \mathrm{ZnF}_{2}(\mathrm{aq})+\mathrm{Br}_{2}(\mathrm{l})$

Set B

$$
\begin{aligned}
& \mathrm{MgCO}_{3}(\mathrm{~s}) \rightarrow \mathrm{MgO}(\mathrm{~s})+\mathrm{CO}_{2}(\mathrm{~g}) \\
& 8 \mathrm{Li}_{2} \mathrm{~S}(\mathrm{~s}) \rightarrow 16 \mathrm{Li}(\mathrm{~s})+\mathrm{S}_{8}(\mathrm{~s}) \\
& 2 \mathrm{H}_{2} \mathrm{O}(\mathrm{l}) \rightarrow 2 \mathrm{H}_{2}(\mathrm{~g})+\mathrm{O}_{2}(\mathrm{~g}) \\
& 2 \mathrm{KClO}_{3}(\mathrm{~s}) \rightarrow 2 \mathrm{KCl}(\mathrm{~s})+3 \mathrm{O}_{2}(\mathrm{~g}) \\
& 2 \mathrm{Na}_{2} \mathrm{O}_{2}(\mathrm{~s}) \rightarrow 2 \mathrm{Na}_{2} \mathrm{O}(\mathrm{~s})+\mathrm{O}_{2}(\mathrm{~g}) \\
& \left(\mathrm{NH}_{4}\right)_{2} \mathrm{CO}_{3}(\mathrm{~s}) \rightarrow 2 \mathrm{NH}_{3}(\mathrm{~g})+\mathrm{H}_{2} \mathrm{O}(\mathrm{l})+\mathrm{CO}_{2}(\mathrm{~g})
\end{aligned}
$$

Set D

$$
\mathrm{AgNO}_{3}(\mathrm{aq})+\mathrm{NaCl}(\mathrm{aq}) \rightarrow \mathrm{AgCl}(\mathrm{~s})+\mathrm{NaNO}_{3}(\mathrm{aq})
$$

$$
2 \mathrm{HNO}_{3}(\mathrm{aq})+\mathrm{Mg}(\mathrm{OH})_{2}(\mathrm{aq}) \rightarrow
$$

$$
\mathrm{Mg}\left(\mathrm{NO}_{3}\right)_{2}(\mathrm{aq})+2 \mathrm{H}_{2} \mathrm{O}(\mathrm{l})
$$

$$
\mathrm{Na}_{2} \mathrm{CO}_{3}(\mathrm{aq})+\mathrm{CaCl}_{2}(\mathrm{aq}) \rightarrow
$$

$$
\mathrm{CaCO}_{3}(\mathrm{~s})+2 \mathrm{NaCl}(\mathrm{aq})
$$

$$
\mathrm{FeS}(\mathrm{~s})+2 \mathrm{HCl}(\mathrm{aq}) \rightarrow \mathrm{H}_{2} \mathrm{~S}(\mathrm{~g})+\mathrm{FeCl}_{2}(\mathrm{aq})
$$

$$
\mathrm{HCl}(\mathrm{aq})+\mathrm{NaOH}(\mathrm{aq}) \rightarrow \mathrm{H}_{2} \mathrm{O}(\mathrm{l})+\mathrm{NaCl}(\mathrm{aq})
$$

$$
\mathrm{FeBr}_{3}(\mathrm{aq})+\mathrm{K}_{3} \mathrm{PO}_{4}(\mathrm{aq}) \rightarrow \mathrm{FePO}_{4}(\mathrm{~s})+3 \mathrm{KBr}(\mathrm{aq})
$$

1. The chemical equations in Model 1 contain the phase notations (s), ( l ), (g), and (aq). Match each symbol with its meaning. dissolved in water liquid solid gas
2. Based on the examples provided, which set(s) of reactions in Model 1 typically involve ions in solution (A, B, C or D)?
3. Based on the examples provided, which set(s) of reactions in Model 1 typically involve gases and/or solids?
4. Match each description below to one of the reactions sets (A, B, C or D) from Model 1.
$\qquad$
_ One compound breaks into elements or smaller compounds.
_ـ Two or more elements or compounds combine to form one product.
_Part of an ionic compound is removed and replaced by a new element.
5. Define the following terms as they are commonly used in the English language.

Synthesis-
Decomposition-
Replacement-
6. The four sets of chemical reactions shown in Model 1 have the following general names. Discuss within your group which name belongs to which set of chemical reactions. Write the name in the appropriate place in Model 1.
Single Replacement Reaction
Double Replacement Reaction
7. Can two elements be used as reactants for a synthesis reactions? If yes, give at least one example from Model 1 to support your answer.
8. Can two compounds be used as reactants for a synthesis reaction? If yes, give at least one example from Model 1 to support your answer.
9. What types of substances (elements or compounds) are seen in the products of decomposition reactions? Use examples from Model 1 to support your answer.
10. In single replacement reactions, do any of the atoms change their charge? If yes, use an example from Model 1 to describe the changes that take place.
11. In double replacement reactions, do any of the atoms change their charge? If yes, use an example from Model 1 to describe the changes that take place.
12. Choose one example from the set of synthesis reactions in Model 1.
a. Write the chemical reaction in reverse.
b. Label the reaction written in part $a$ with one of the reaction types in Model 1.
13. Identify each of the reactions below as synthesis (S), decomposition (D), single replacement (SR) or double replacement (DR).
$\longrightarrow \quad \mathrm{K}_{2} \mathrm{O}(\mathrm{s})+\mathrm{H}_{2} \mathrm{O}(\mathrm{l}) \rightarrow 2 \mathrm{KOH}(\mathrm{aq})$
$\longrightarrow \quad 2 \mathrm{MgCl}_{2}(\mathrm{aq})+\mathrm{Na}_{2} \mathrm{CO}_{3}(\mathrm{aq}) \rightarrow 2 \mathrm{NaCl}(\mathrm{aq})+\mathrm{MgCO}_{3}(\mathrm{~s})$
$-2 \mathrm{Al}_{2} \mathrm{O}_{3}(\mathrm{~s}) \rightarrow 4 \mathrm{Al}(\mathrm{s})+3 \mathrm{O}_{2}(\mathrm{~g})$
$\longrightarrow \mathrm{Cu}\left(\mathrm{NO}_{3}\right)_{2}(\mathrm{aq})+\mathrm{Zn}(\mathrm{s}) \rightarrow \mathrm{Cu}(\mathrm{s})+\mathrm{Zn}\left(\mathrm{NO}_{3}\right)_{2}(\mathrm{aq})$
$-\mathrm{H}_{2} \mathrm{SO}_{4}(\mathrm{aq})+2 \mathrm{NaOH}(\mathrm{aq}) \rightarrow \mathrm{Na}_{2} \mathrm{SO}_{4}(\mathrm{aq})+2 \mathrm{H}_{2} \mathrm{O}(\mathrm{l})$
$-2 \mathrm{~K}(\mathrm{~s})+2 \mathrm{H}_{2} \mathrm{O}(\mathrm{l}) \rightarrow 2 \mathrm{KOH}(\mathrm{aq})+\mathrm{H}_{2}(\mathrm{~g})$
$-2 \mathrm{O}_{2}(\mathrm{~g})+\mathrm{N}_{2}(\mathrm{~g}) \rightarrow \mathrm{N}_{2} \mathrm{O}_{4}(\mathrm{~g})$
$\longrightarrow \quad 2 \mathrm{NaF}(\mathrm{s}) \rightarrow 2 \mathrm{Na}(\mathrm{s})+\mathrm{F}_{2}(\mathrm{~g})$
14. A student writes the following incorrect chemical equation for the synthesis of magnesium oxide.
$\mathrm{Mg}+\mathrm{O}_{2} \rightarrow \mathrm{MgO}_{2}$
Another student writes the following incorrect synthesis reaction.
$\mathrm{Mg}+\mathrm{O} \rightarrow \mathrm{MgO}$
a. What is the correct formula for magnesium oxide? Hint: Magnesium oxide is an ionic compound.
b. What is the correct formula for elemental oxygen?
c. Describe the error made by the first student.
d. Describe the error made by the second student.
$e$. Write the correct balanced chemical equation for the synthesis of magnesium oxide.
15. A student writes the following incorrect chemical equation for a single replacement reaction between lithium bromide and fluorine.
$2 \mathrm{LiBr}(\mathrm{aq})+\mathrm{F}_{2}(\mathrm{~g}) \rightarrow 2 \mathrm{Li}(\mathrm{s})+2 \mathrm{FBr}(\mathrm{g})$
a. In a single replacement reaction, part of an ionic compound is removed and replaced by a new element. What element will fluorine replace in lithium bromide? Hint: What is the most common ionic form of fluorine?
b. What is wrong with the student's prediction of the products in the above reaction?
c. Predict the products and write the correct balanced equation for the single replacement reaction between lithium bromide and fluorine.
16. A student writes the following incorrect chemical equation for a double replacement reaction between iron(III) bromide and sodium hydroxide solutions.
$\mathrm{FeBr}_{3}(\mathrm{aq})+\mathrm{NaOH}(\mathrm{aq}) \rightarrow \mathrm{FeOH}(\mathrm{s})+\mathrm{NaBr}_{3}(\mathrm{aq})$
a. What is wrong with the chemical formula(s) of the product(s) predicted by this student?
b. Write the correct equation for the double replacement reaction between iron(III) bromide and sodium hydroxide.
17. Consider the following chemical reaction written as a word equation.
diphosphorus pentoxide + water $\rightarrow$ phosphoric acid
a. Identify the type of chemical reaction from Model 1 that would describe this reaction.
b. Write chemical formulas under the names of the substances in the word equation.
c. Balance the chemical equation.

## Read This!

Chemists use their knowledge of synthesis, decomposition, single replacement, and double replacement to predict what will happen in chemical reactions. When predicting the products for a reaction it is important to remember that atoms or ions will only combine in ways that make them stable, otherwise the reaction will not happen under normal conditions. This means that it is important to pay attention to ion charges, the natural state of elements, and the formulas of common molecular substances like carbon dioxide and water. It is only after predicting the products and writing the correct formulas that a chemist would then apply the law of conservation of mass and balance the chemical equation using coefficients as needed.
18. Use your understanding of common chemical reactions to predict the products for the following reactions. Writing a word equation may be helpful. Balance the chemical equations after you have written the correct chemical formulas for all of the reactants and products.
a. $\mathrm{Al}(\mathrm{s})+\mathrm{N}_{2}(\mathrm{~g}) \rightarrow$
b. dinitrogen oxide $(\mathrm{g}) \rightarrow$
c. $\mathrm{SrCl}_{2}(\mathrm{aq})+2 \mathrm{AgNO}_{3}(\mathrm{aq}) \rightarrow$
d. chromium(III) nitrate(aq) + zinc chloride (aq) $\rightarrow$
e. $2 \mathrm{Na}(\mathrm{s})+\mathrm{Cl}_{2}(\mathrm{~g}) \rightarrow$
f. $\mathrm{Zn}(\mathrm{s})+2 \mathrm{HCl}(\mathrm{aq}) \rightarrow$

## TYPES OF CHEMICAL REACTIONS

(A) SYNTHESIS (or Combination): two or more substances combine to form a single substance. The general formula for this reaction is given below.

$$
\begin{gathered}
\mathbf{A}+\mathbf{B} \rightarrow \mathbf{A B} \\
\text { Examples: } \\
2 \mathrm{H}_{2}+\mathrm{O}_{2} \rightarrow 2 \mathrm{H}_{2} \mathrm{O} \\
\mathrm{CaO}+\mathrm{H}_{2} \mathrm{O} \rightarrow \mathrm{Ca}(\mathrm{OH})_{2}
\end{gathered}
$$

(B) DECOMPOSITION: a single compound is broken down into two or more less complex products (elements or compounds). The general formula for this reaction is given below.

$$
\begin{gathered}
\mathbf{A B} \rightarrow \mathbf{A}+\mathbf{B} \\
\text { Examples: } \\
\mathrm{CaCO}_{3} \rightarrow \mathrm{CaO}+\mathrm{CO}_{2} \\
2 \mathrm{KClO}_{3} \rightarrow 2 \mathrm{KCl}+3 \mathrm{O}_{2}
\end{gathered}
$$

(C) SINGLE REPLACEMENT: atoms of one element replace the atoms of a second element in a compound. The general formula for this reaction is given below.

$$
\begin{gathered}
\mathbf{A}+\mathbf{B C} \rightarrow \mathbf{A C}+\mathbf{B} \\
\text { Examples: } \\
\mathrm{Mg}+2 \mathrm{AgNO}_{3} \rightarrow \mathrm{Mg}\left(\mathrm{NO}_{3}\right)_{2}+2 \mathrm{Ag} \\
\mathrm{Cl}_{2}+2 \mathrm{KBr}_{\mathrm{KB}} \rightarrow \mathrm{Br}_{2}+2 \mathrm{KCl}
\end{gathered}
$$

(D) DOUBLE REPLACEMENT: Two compounds reacting to form two new compounds. The general formula for this reaction is given below.

$$
\begin{gathered}
\mathbf{A B}+\underset{\text { ED }}{\text { Examples: }} \boldsymbol{A D}+\mathbf{C B} \\
\mathrm{FeS}+2 \underset{\mathrm{HCl}}{\mathrm{HC} \mathrm{H}_{2} \mathrm{~S}+\mathrm{FeCl}_{2}} \\
\mathrm{HCl}+\mathrm{NaOH} \rightarrow \mathrm{NaCl}+\mathrm{H}_{2} \mathrm{O}
\end{gathered}
$$

(E) COMBUSTION: A carbon compound is burned in oxygen to form carbon dioxide and water. This reaction is very specific. The only variable is the carbon compound that is being burned.

$$
\text { Carbon compound }+\mathrm{O}_{2} \rightarrow \mathrm{CO}_{2}+\mathrm{H}_{2} \mathrm{O}
$$

Examples:

$$
\begin{gathered}
\mathrm{CH}_{4}+2 \mathrm{O}_{2} \rightarrow \mathrm{CO}_{2}+2 \mathrm{H}_{2} \mathrm{O} \\
2 \mathrm{C}_{8} \mathrm{H}_{18}+25 \mathrm{O}_{2} \rightarrow 16 \mathrm{CO}_{2}+18 \mathrm{H}_{2} \mathrm{O}
\end{gathered}
$$


[^0]:    At the End of this Lesson - You should be able to:

    - Identify molecular substances
    - Name molecular substances from formula
    - Write the formulas from the names of molecular substances.

