Name:

Regents Chemistry: Mrs. Mintz

Practice Packet

Chapter 7: Formulas & Chemical Equations

Naming Ionic Compounds

What are the structural units that make up ionic compounds and how are they named?

Why?

When working in chemistry, it is often convenient to write a chemical in symbols. For example we might write down the substance table salt as NaCl. In talking about chemistry however, it is a bit tacky to say "en-ay see-ell" when we want to refer to a substance. Also, in formal writing we should use the name of the compound rather than its symbols. Therefore we need to learn how to say the proper names of ionic substances.

Model 1 – Ion Charges for Selected Elements

1	H^+										
2	Li^+	Be^{2+}						N^{3-}	O^{2-}	F^{1-}	
3	Na^+	Mg^{2+}	Transition elements				Al^{3+}		P^{3-}	S^{2-}	Cl^{1-}	
4	K^+	Ca^{2+}	Fe^{2+} Fe^{3+}	Ni^{2+} Ni^{3+}	Cu^+ Cu^{2+}	Zn^{2+}					Br^{1-}	
5	Rb^+	Sr^{2+}			Ag^{1+}			Sn^{2+} Sn^{4+}			I^{1-}	
6		Ba^{2+}				Hg_2^{2+} Hg^{2+}		Pb^{2+} Pb^{4+}				

Cations → ← Anions

1. Based on the information in Model 1:
   a. Identify three elements that form only one cation.

   b. Identify three elements that form only one anion.

   c. Identify three elements that form more than one cation.

   d. In what region of the periodic table are these "multiple ion" elements usually located?

2. Consider the ions of potassium (K) and sulfur (S). Write chemical formulas for all possible ionic compounds involving these ions, using the simplest ratio(s) of potassium (K) and sulfur (S). Keep in mind that the sum of the charges in an ionic compound must equal zero.

3. Consider the ions of iron (Fe) and sulfur (S). Write chemical formulas for all possible ionic compounds involving these ions, using the simplest ratio(s) of iron (Fe) and sulfur (S). Keep in mind that the sum of the charges in an ionic compound must equal zero.

Model 2 – Ionic Compound Names (Metals that form one ion)

NaCl	Sodium chloride	Zn_3P_2	Zinc phosphide
CaS	Calcium sulfide	Al_2O_3	Aluminum oxide
Ag_2S	Silver sulfide	$SrCl_3$	Strontium chloride

4. Circle the symbol for the metal in each of the compounds in Model 2.
5. Which element comes first in the name and formula of the compounds in Model 2—the metal or the nonmetal?

6. Use the table of ions in Model 1 to answer the following questions:
   a. In the compound zinc phosphide, what is the charge on the zinc ion?

   b. In the compound zinc phosphide, what is the charge on the phosphide ion?

7. Explain why a 3 to 2 ratio of ions is necessary for the compound zinc phosphide.

8. The compound carbon dioxide has a name that gives you a hint as to how many oxygen atoms are in the compound. Is there anything in the name "zinc phosphide" that indicates there are three zinc and two phosphorus ions in the formula unit?

9. Is there any other ratio of zinc and phosphorus ions that could exist? For instance, could you have Zn_2P or ZnP_2? Explain your answer.

10. Explain why you don't need to specify the number of ions in the compound when you are naming ionic substances like those in Model 2.

11. Model 2 is labeled "Metals that form one ion." What other metals that also form only one ion could be included in the Model 2 list? Model 1 may be helpful in this regard.

12. Describe how the names of the nonmetal elements in Model 2 are changed when they are in their anion forms.

13. Name the following ionic compounds using what you learned from Model 2.

    Li_2O MgF_2 Al_2S_3 K_3N

14. Provide the chemical formula for each of the following ionic compounds.

    Barium chloride Magnesium oxide

15. Consider the two chemical formulas you wrote in Question 3 for compounds of iron and sulfur. Would the name "iron sulfide" be sufficient to uniquely identify either of those compounds? Explain.

Read This!

When the metal in an ionic compound always forms an ion with the same charge, you need not indicate that charge as part of the compound name. However, some atoms have the ability to form more than one type of ion. This can make naming confusing. You can't simply refer to a compound of copper and oxygen as "copper oxide." People won't know which compound you are referring to—CuO or Cu_2O.

Model 3 – Ionic Compound Names (Metals that form multiple ions)

Cu_2O	Copper(I) oxide	PbO	Lead(II) oxide
CuO	Copper(II) oxide	PbO_2	Lead(IV) oxide
SnF_2	Tin(II) fluoride	$FeCl_2$	Iron(II) chloride
SnF_4	Tin(IV) fluoride	$FeCl_3$	Iron(III) chloride

16. Model 3 is labeled "Metals that form multiple ions." What other metals that form multiple ions could be included in Model 3? Model 1 may be helpful in this regard.

17. Describe the most obvious difference between the names in Model 3 and those in Model 2.

18. Do the Roman numerals in the names in Model 3 relate to the number of cations or number of anions in the formula unit? Support your answer by citing two specific examples.

19. Keeping in mind that the sum of the charges in an ionic compound must equal zero, use the chemical formulas in Model 3 to answer the following questions:

    a. Identify the charge on the copper cations in copper(I) oxide and copper(II) oxide, respectively.

    b. Identify the charge on the iron cations in iron(II) chloride and iron(III) chloride, respectively.

20. What do the Roman numerals in the compounds described in Question 19 indicate?

21. Fill in the table below using what you've learned from Model 3.

Compound	Charge on Cation	Name of the Compound
$PbCl_4$	Pb^{4+}	Lead(IV) chloride
Fe_2O_3		
SnO		
$CuBr_2$		

22. For each of the compounds in the table below, determine the type of metal in the compound and then name the compound using the correct naming method.

	Metal forms only one ion	Metal forms multiple ions	Name
$CaBr_2$			
MgO			
Ag_3N			
$SnCl_2$			
CuF_2			
K_3P			
Zn_3N_2			
HgO			

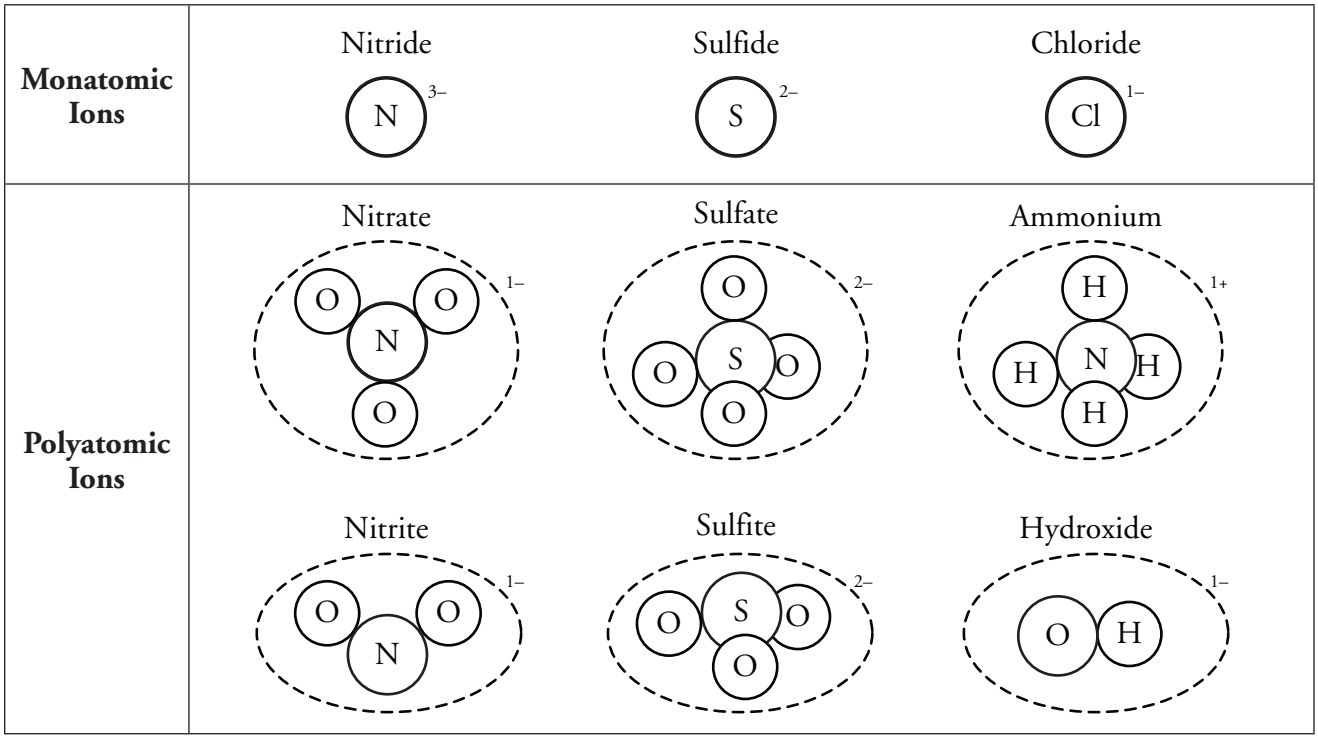
Polyatomic Ions

Can a group of atoms have a charge?

Why?

Do you know you eat a lot of "-ates"? Next time you look at a food label, read the ingredients and you will likely find a number of ingredients that end with "-ate," such as sodium phosphate or calcium carbonate. Did you ever wonder what the chemical formulas of these ingredients look like? In this activity we will explore polyatomic ions, which are groups of atoms that carry a charge. These ions are found in our food ingredients, natural waterways, and many other chemical compounds you encounter every day.

Model 1 – Types of Ions



1. Use Model 1 to complete the table below.

Name of Ion	Nitride	Nitrate	Sulfate	Sulfite	Ammonium
Charge on Ion		-1			
Type and Number of Atoms			1 sulfur 4 oxygen		
Chemical Formula				SO_3^{2-}	

2. Consider the terms "monatomic" and "polyatomic" as they are used in Model 1. Write a definition for each of these terms. It may be helpful to break the words apart (*i.e.,* poly – atomic). Make sure your group comes to consensus.

   Monatomic—

   Polyatomic—

3. What types of elements (metals or nonmetals) are shown in the polyatomic ions in Model 1?

4. The net charge on a sulfide ion (S^{2-}) is –2. Explain how this ion obtains its charge. Your answer should include a discussion of subatomic particles.

5. The dotted line around each polyatomic ion in Model 1 shows that the group of atoms has a charge. The charge is not on any one atom, but rather on the group of atoms as a whole. Based on your knowledge of monatomic ions, propose an explanation for the net charge on a polyatomic ion. Your answer should include a discussion of subatomic particles.

6. What are the similarities and differences between the nitrate and nitrite ions in Model 1?

7. What are the similarities and differences between the sulfate and sulfite ions in Model 1?

8. The "chlorate" polyatomic ion has a charge of –1 and is composed of one chlorine atom (the central atom) and three oxygen atoms.

   a. Draw a model of a chlorate ion.

b. Write the chemical formula for the chlorate ion, including its charge.

9. In your group discuss what "chlorite" would look like.

a. Draw a model of a chlorite ion.

b. Write the chemical formula for the chlorite ion, including its charge.

Model 2 – Common Polyatomic Ions

1+		1–		2–		3–	
ammonium	NH_4^{1+}	acetate	CH_3COO^{1-}	sulfate	SO_4^{2-}	phosphate	PO_4^{3-}
		hydroxide	OH^{1-}	sulfite	SO_3^{2-}		
		nitrate	NO_3^{1-}	carbonate	CO_3^{2-}		
		nitrite	NO_2^{1-}	chromate	CrO_4^{2-}		
		bicarbonate	HCO_3^{1-}	dichromate	$Cr_2O_7^{2-}$		
		permanganate	MnO_4^{1-}				
		perchlorate	ClO_4^{1-}				
		chlorate	ClO_3^{1-}				
		chlorite	ClO_2^{1-}				
		hypochlorite	ClO^{1-}				

10. What is the only polyatomic ion that is a cation?

11. How are bicarbonate and carbonate related?

12. Predict the chemical formula and charge for the bisulfate ion.

13. How are chromate and dichromate related?

14. Bromine forms polyatomic ions with structures similar to those of chlorine. Using the chlorine family of polyatomic ions as a model, predict the name of the BrO_4^{1-} ion.

15. Identify the polyatomic ion in each of these ionic compounds. Write out the name and formula of the ions including their charges.

    a. $CaCO_3$ *b.* $Mg(OH)_2$ *c.* NH_4Cl

Model 3 – Ternary Ionic Compounds

Compound Name	Ion Symbols and Charges		Chemical Formula
Ammonium phosphate	NH_4^{1+}	PO_4^{3-}	$(NH_4)_3PO_4$
Barium nitrite	Ba^{2+}	NO_2^{1-}	$Ba(NO_2)_2$
Ammonium sulfate	NH_4^{1+}	SO_4^{2-}	$(NH_4)_2SO_4$
Aluminum carbonate	Al^{3+}	CO_3^{2-}	$Al_2(CO_3)_3$
Iron(III) hydroxide	Fe^{3+}	OH^{1-}	$Fe(OH)_3$
Potassium nitrate	K^{1+}	NO_3^{1-}	KNO_3

16. How are ternary ionic compounds in Model 3 different from binary ionic compounds (NaCl, MgO, $CaBr_2$, etc.) that you've seen previously? *Hint:* Consider the meaning of the word "**bi**nary."

17. Consider the compound iron(III) hydroxide in Model 3.

    a. How many hydroxide ions (OH^{1-}) are combined with an iron(III) ion (Fe^{3+})?

    b. Is your answer to part *a* the only combination of iron(III) and hydroxide that should exist in nature? Explain.

18. Consider the compound barium nitrite in Model 3.

    a. What does the subscripted "2" *inside* the parentheses of the chemical formula tell you about the compound?

$$Ba(NO_2)_2$$

b. What does the subscripted "2" *outside* the parentheses of the chemical formula tell you about the compound?

$$Ba(NO_2)_2$$

19. How many atoms of each element are in one formula unit of ammonium phosphate, $(NH_4)_3PO_4$?

nitrogen hydrogen phosphorus oxygen

20. A student writes the chemical formula for the ionic compound calcium hydroxide as $CaOH_2$.

a. Write the chemical formula for each ion in the compound.

Calcium: Hydroxide:

b. Why is the student's chemical formula for the compound calcium hydroxide wrong?

21. Many of the chemical formulas in Model 3 include parentheses. Which one of the following rules summarizes the appropriate use of parentheses in ternary ionic compounds? For the three rules that do not apply in all cases, show at least one counter example from the chemical formulas in Model 3.

*Parentheses are used around any ion that is used more than once in a formula unit.

*Parentheses are used around any polyatomic ion.

*Parentheses are used around any polyatomic ion used more than once in a formula unit.

*Parentheses are only used around polyatomic anions used more than once in a formula unit.

22. Write chemical formulas for the following ternary ionic compounds.

a. Calcium sulfate *b.* Copper(II) nitrate *c.* Lithium phosphate

d. Potassium permanganate *e.* Aluminum sulfite *f.* Magnesium bicarbonate

23. Name the following ternary ionic compounds.

a. $BaSO_4$ *b.* NH_4NO_3 *c.* $K_2Cr_2O_7$

d. $Fe(NO_3)_3$ *e.* $Mg(CH_3COO)_2$ *f.* $Al_2(CO_3)_3$

Naming Molecular Compounds

How are the chemical formula and name of a molecular compound related?

Why?

When you began chemistry class this year, you probably already knew that the chemical formula for carbon dioxide was CO_2. Today you will find out why CO_2 is named that way. Naming chemical compounds correctly is of paramount importance. The slight difference between the names carbon monoxide (CO, a poisonous, deadly gas) and carbon dioxide (CO_2, a greenhouse gas that we exhale when we breathe out) can be the difference between life and death! In this activity you will learn the naming system for molecular compounds.

Model 1 – Molecular Compounds

Molecular Formula	Number of Atoms of First Element	Number of Atoms of Second Element	Name of Compound
ClF			Chlorine monofluoride
ClF_5	1	5	Chlorine pentafluoride
CO			Carbon monoxide
CO_2			Carbon dioxide
Cl_2O			Dichlorine monoxide
PCl_5			Phosphorus pentachlroride
N_2O_5			Dinitrogen pentoxide

1. Fill in the table to indicate the number of atoms of each type in the molecular formula.
2. Examine the molecular formulas given in Model 1 for various molecular compounds.
   a. How many different *elements* are present in each compound shown?

   b. Do the compounds combine metals with metals, metals with nonmetals, or nonmetals with nonmetals?

3. Find all of the compounds in Model 1 that have chlorine and fluorine in them. Explain why the name "chlorine fluoride" is not sufficient to identify a specific compound.

4. Assuming that the name of the compound gives a clue to its molecular formula, predict how many atoms each of these prefixes indicates, and provide two examples.

   mono-

   di-

   penta-

Model 2 – Prefixes and Suffixes

Prefix	Numerical Value
mono-	
di-	
tri-	
tetra-	
penta-	
hexa-	
hepta-	
octa-	
nona-	
deca-	

Molecular Formula	Name of Compound
BCl_3	Boron trichloride
SF_6	Sulfur hexafluoride
IF_7	Iodine heptafluoride
NI_3	Nitrogen triiodide
N_2O_4	Dinitrogen tetroxide
Cl_2O	Dichlorine monoxide
P_4O_{10}	Tetraphosphorus decoxide
B_5H_9	Pentaboron nonahydride
Br_3O_8	Tribromine octoxide
ClF	Chlorine monofluoride

5. Examine the prefixes in Model 2. Fill in the numerical value that corresponds to each prefix.
6. What suffix (ending) do all the compound names in Model 2 have in common?

7. Carefully examine the names of the compounds in Model 2. When is a prefix NOT used in front of the name of an element?

8. Consider the compound NO.
   a. Which element, nitrogen or oxygen, would require a prefix in the molecule name? Explain your answer.

   b. Name the molecule NO.

9. Find two compounds in Model 2 that contain a subscript of "4" in their molecular formula.
   a. List the formulas and names for the two compounds.

   b. What is different about the spelling of the prefix meaning "four" in these two names?

10. Find two compounds in Model 2 that contain the prefix "mono-" in their names.

    a. List the formulas and names for the two compounds.

    b. What is different about the spelling of the prefix meaning "one" in these two names?

11. Identify any remaining names of compounds in Model 2 where the prefixes that do not exactly match the spelling shown in the prefix table.

12. Use your answers to Questions 9–11 to write a guideline for how and when to modify a prefix name for a molecular compound. Come to a consensus within your group.

13. Would the guideline you wrote for Question 12 give you the correct name for NI_3 as it is given in Model 2? If not, modify your guideline to include this example.

14. All of the compounds listed in Model 2 are binary molecular compounds. Compounds such as CH_3OH or PF_2Cl_3 are not binary, and compounds such as NaCl or $CaCl_2$ are not molecular. Propose a definition for "binary molecular compounds."

15. Collaborate with your group members to write a list of rules for recognizing and naming binary molecular compounds from their chemical formulas.

16. For each of the following compounds, indicate whether or not your naming rules from Question 15 will apply. If not, explain why the naming rules do not apply.

FeI_3 ICl_5 $HBrO_4$

17. Using the rules your group developed in Question 15, name each of the following molecular compounds.

Molecular Formula	**Molecule Name**
PBr_3	
SCl_4	
N_2F_2	
SO_3	
BrF	

18. Write molecular formulas for the following compounds.

Molecular Formula	**Molecule Name**
	Disulfur decafluoride
	Carbon tetrachloride
	Oxygen difluoride
	Dinitrogen trioxide
	Tetraphosphorus heptasulfide

Compounds: Putting it all Together

Name: _____

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. $Fe(NO_2)_3$	
2. $Na_2S_2O_3$	
3. P_2O_5	
4. $BaBr_2$	
5. $Mn_2(Cr_2O_7)_7$	
6. $CaCl_2$	
7. $(NH_4)_2S$	
8. CuF	
9. Br_2O	
10. $HgSO_4$	
11. Al_2O_3	
12. SCl_6	
13. IF_7	
14. $Cr(CO_3)_3$	
15. 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	

Formula Writing & Naming Review

1. In the formula $X_2(SO_4)_3$, the *X* represents a metal. This metal could be located on the Periodic Table in

   1) Group1 3) Group 13
   2) 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 *M*Cl

   1) Rb 2) Ra 3) Re 4) Rn

4. Which formula represents strontium phosphate?

   1) $SrPO_4$ 3) $Sr_2(PO_4)_3$
   2) Sr_3PO_8 4) $Sr_3(PO_4)_2$

5. The compound *X*Cl is classified as ionic if *X* represents the element

   1) H 2) I 3) Rb 4) Br

6. What is the chemical formula for iron(III) oxide?

   1) FeO 3) Fe_3O
   2) Fe_2O_3 4) Fe_3O_2

7. In which compound is the ratio of metal ions to nonmetal ions 1 to 2?

   1) calcium bromide 3) calcium phosphide
   2) calcium oxide 4) calcium sulfide

8. Element *X* reacts with iron to form two different compounds with the formulas Fe*X* and Fe_2X_3 . To which group on the Periodic Table does element *X* belong?

   1) Group 8 3) Group 13
   2) Group 2 4) Group 16

9. What is the chemical formula for sodium sulfate?

   1) Na_2SO_3 3) $NaSO_3$
   2) Na_2SO_4 4) $NaSO_4$

10. What is the IUPAC name for the compound ZnO?

    1) zinc oxide 3) zinc peroxide
    2) zinc oxalate 4) zinc hydroxide

11. What is the chemical formula of iron(III) sulfide?

    1) FeS 3) $FeSO_3$
    2) Fe_2S_3 4) $Fe_2(SO_3)_3$

12. Which formula represents copper(I) oxide?

    1) CuO 3) Cu_2O
    2) CuO_2 4) Cu_2O_2

13. Which formula represents lead(II) chromate?

    1) $PbCrO_4$ 3) Pb_2CrO_4
    2) $Pb(CrO_4)_2$ 4) $Pb_2(CrO_4)_3$

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 3) iron(III) oxide
    2) iron(II) oxide 4) iron trioxide

15. What is the IUPAC name for the compound FeS?

    1) iron(II) sulfate 3) iron(II) sulfide
    2) iron(III) sulfate 4) Iron(III) sulfide

16. What is the formula of titanium(II) oxide?

    1) TiO 2) TiO_2 3) Ti_2O 4) Ti_2O_3

17. Which is a binary compound?

    1) $CaCl_2$ 3) $NaNO_3$
    2) KOH 4) $MgSO_4$

18. What is the correct formula for ammonium carbonate?

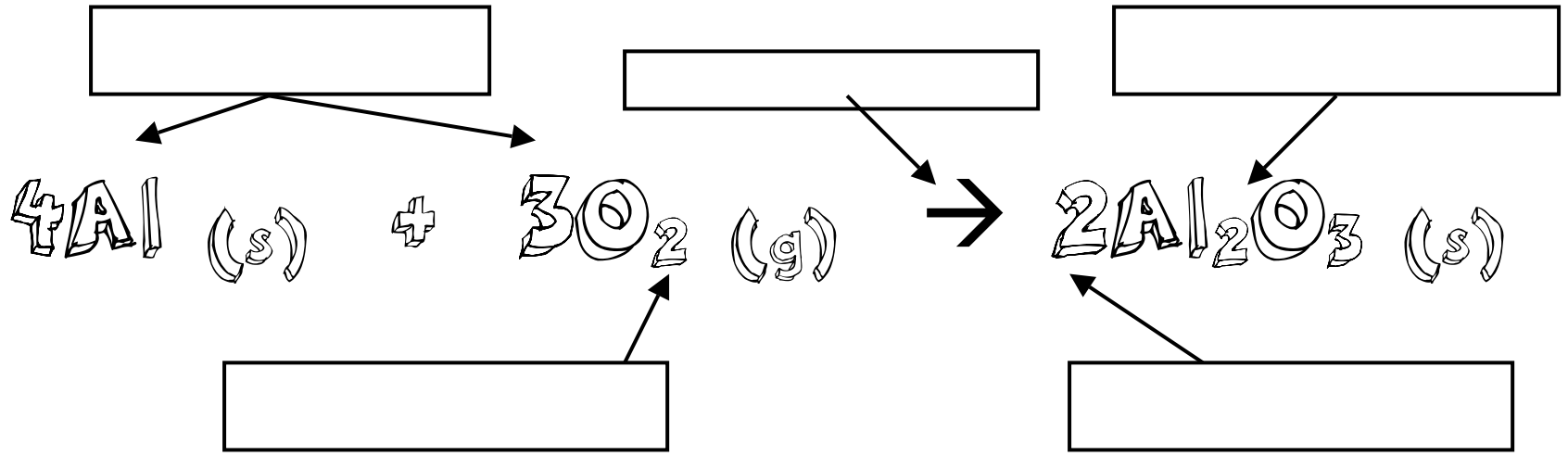
    1) $NH_4(CO_3)_2$ 3) $(NH_4)_2(CO_3)_2$
    2) NH_4CO_3 4) $(NH_4)_2CO_3$

Chemical Equations

Name: _____

THE ANATOMY OF A CHEMICAL EQUATION

Part A: Label the chemical equation using PRODUCT, REACTANTS, SUBSCRIPT, COEFFICIENT and YEILDS.



Part B: Parts & Pieces:

1. Circle each subscript.
2. Draw a square around each coefficient.
3. Answer the questions related to each chemical formula.

O_2

What element does the O represent?

_____

CO_2

How many atoms of each element are shown?

C = _____ O = _____

$5H_2$

How many atoms of Hydrogen are in this formula as shown?

_____

$2C_2H_6$

How many atoms of each element are shown in the formula?

C = _____ H = _____

$2Na_2SO_4$

How many atoms of each element are shown in the formula?

Na = _____ S = _____ O = _____

NUMBER OF ATOMS IN A FORMULA

Name _____

Determine the number of atoms in the following chemical formulas.

1. $NaCl$ _____
2. H_2SO_4 _____
3. KNO_3 _____
4. $CaCl_2$ _____
5. C_2H_6 _____
6. $Ba(OH)_2$ _____
7. NH_4Br _____
8. $Ca_3(PO_4)_2$ _____
9. $Al_2(SO_4)_3$ _____
10. $Mg(NO_3)_2$ _____
11. $Cu(NO_3)_2$ _____
12. $KMnO_4$ _____
13. H_2O_2 _____
14. H_3PO_4 _____
15. $(NH_4)_3PO_4$ _____
16. Fe_2O_3 _____
17. $NaC_2H_3O_2$ _____
18. $Mg(C_2H_3O_2)_2$ _____
19. Hg_2Cl_2 _____
20. K_2SO_3 _____

Name: _____

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. _____ Ca + _____ O_2 → _____ CaO

2. _____ Mg + _____ HCl → _____ H_2 + _____ $MgCl_2$

3. _____ $AgNO_3$ + _____ Na_2S → _____ Ag_2S + _____ $NaNO_3$

4. _____ HCl + _____ Fe_2O_3 → _____ H_2O + _____ $FeCl_3$

5. _____ $AlBr_3$ + _____ K_2SO_4 → _____ KBr + _____ $Al_2(SO_4)_3$

6. _____ S + _____ O_2 → _____ SO_3

7. _____ Zn + _____ HCl → _____ $ZnCl_2$ + _____H_2

8. _____ Na + _____ Cl_2 → _____ $NaCl$

9. _____ Al_2O_3 → _____ Al + _____O_2

10. _____ $LiBr$ + _____ F_2 → _____ Br_2 + _____ LiF

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 _____

$4Fe(s) + 3O_2(g) \rightarrow 2Fe_2O_3(s)$

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

$2SO_2(g) + O_2(g) \rightarrow 2SO_3(g)$

$MgO(s) + H_2O(l) \rightarrow Mg(OH)_2(aq)$

$P_2O_5(g) + 3H_2O(l) \rightarrow 2H_3PO_4(aq)$

$SO_3(g) + H_2O(l) \rightarrow H_2SO_4(aq)$

Set B _____

$MgCO_3(s) \rightarrow MgO(s) + CO_2(g)$

$8Li_2S(s) \rightarrow 16Li(s) + S_8(s)$

$2H_2O(l) \rightarrow 2H_2(g) + O_2(g)$

$2KClO_3(s) \rightarrow 2KCl(s) + 3O_2(g)$

$2Na_2O_2(s) \rightarrow 2Na_2O(s) + O_2(g)$

$(NH_4)_2CO_3(s) \rightarrow 2NH_3(g) + H_2O(l) + CO_2(g)$

Set C _____

$2FeCl_3(aq) + 3Zn(s) \rightarrow 2Fe(s) + 3ZnCl_2(aq)$

$2Al(NO_3)_3(aq) + 3Ca(s) \rightarrow 3Ca(NO_3)_2(aq) + 2Al(s)$

$Mg(s) + CuSO_4(aq) \rightarrow MgSO_4(aq) + Cu(s)$

$2Al(s) + 6HCl(aq) \rightarrow 2AlCl_3(aq) + 3H_2(g)$

$Cl_2(g) + 2NaBr(aq) \rightarrow 2NaCl(aq) + Br_2(l)$

$ZnBr_2(aq) + F_2(g) \rightarrow ZnF_2(aq) + Br_2(l)$

Set D _____

$AgNO_3(aq) + NaCl(aq) \rightarrow AgCl(s) + NaNO_3(aq)$

$2HNO_3(aq) + Mg(OH)_2(aq) \rightarrow Mg(NO_3)_2(aq) + 2H_2O(l)$

$Na_2CO_3(aq) + CaCl_2(aq) \rightarrow CaCO_3(s) + 2NaCl(aq)$

$FeS(s) + 2HCl(aq) \rightarrow H_2S(g) + FeCl_2(aq)$

$HCl(aq) + NaOH(aq) \rightarrow H_2O(l) + NaCl(aq)$

$FeBr_3(aq) + K_3PO_4(aq) \rightarrow FePO_4(s) + 3KBr(aq)$

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.

   _____ Ionic compounds dissolved in water switch partners.

   _____ One compound breaks into elements or smaller compounds.

   _____ 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 — Synthesis Reaction

   Double Replacement Reaction — Decomposition 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).

    _____ $K_2O(s) + H_2O(l) \rightarrow 2KOH(aq)$

    _____ $2MgCl_2(aq) + Na_2CO_3(aq) \rightarrow 2NaCl(aq) + MgCO_3(s)$

    _____ $2Al_2O_3(s) \rightarrow 4Al(s) + 3O_2(g)$

    _____ $Cu(NO_3)_2(aq) + Zn(s) \rightarrow Cu(s) + Zn(NO_3)_2(aq)$

    _____ $H_2SO_4(aq) + 2NaOH(aq) \rightarrow Na_2SO_4(aq) + 2H_2O(l)$

    _____ $2K(s) + 2H_2O(l) \rightarrow 2KOH(aq) + H_2(g)$

    _____ $2O_2(g) + N_2(g) \rightarrow N_2O_4(g)$

    _____ $2NaF(s) \rightarrow 2Na(s) + F_2(g)$

14. A student writes the following incorrect chemical equation for the synthesis of magnesium oxide.

    $Mg + O_2 \rightarrow MgO_2$

    Another student writes the following incorrect synthesis reaction.

    $Mg + O \rightarrow MgO$

    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.

    $2LiBr(aq) + F_2(g) \rightarrow 2Li(s) + 2FBr(g)$

    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.

    $FeBr_3(aq) + NaOH(aq) \rightarrow FeOH(s) + NaBr_3(aq)$

    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 → 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. $Al(s) + N_2(g) \rightarrow$

    b. dinitrogen oxide(g) $\rightarrow$

    c. $SrCl_2(aq) + 2AgNO_3(aq) \rightarrow$

    d. chromium(III) nitrate(aq) + zinc chloride(aq) $\rightarrow$

    e. $2Na(s) + Cl_2(g) \rightarrow$

    f. $Zn(s) + 2HCl(aq) \rightarrow$