Science 10 Unit A Chemistry

Reactions and Balancing Chemical Equations

Review: Nomenclature - Name each compound.

$MgCl_2$ = _____

$AlBr_3$ = _____

MnO = _____

NO_3 = _____

Review: Nomenclature - Write the formula for each compound.

tin (IV) oxide = _____

lithium hydroxide = _____

tetraphosphorus decaoxide = _____

sulfurous acid = _____

States of Matter

When writing equations, we indicate which state of matter the reactants and products are in by writing a letter in subscripts behind the compound. The states are:

STATE	abbr.
solid	(s)
liquid	(l)
gas	(g)
aqueous	(aq)

Determining State:

Most compounds are either solids or aqueous (I'll show you some hints for figuring out liquids and gases later).

So our main job is determining if a compound is solid or aqueous.

The Solubility Table

The solubility table allows you to tell the state (solid or aqueous) of an ionic compound.

Solubility of Some Common Ionic Compounds in Water at 298.15 K (25°C)

Ion	Group 1 NH_4^+ $H^+(H_3O^+)$	ClO_3^- NO_3^- ClO_4^-	CH_3COO^-	Cl^- Br^- I^-	SO_4^{2-}	S^{2-}	OH^-	PO_4^{3-} SO_3^{2-} CO_3^{2-}
Solubility greater than or equal to 0.1 mol/L (very soluble)	all	all	most	most	most	Group 1 Group 2 NH_4^+	Group 1 NH_4^+ Sr^{2+} Ba^{2+} Tl^+	Group 1 NH_4^+
Solubility less than 0.1 mol/L (slightly soluble)	none	none	Ag^+	Ag^+ Pb^{2+} Hg_2^{2+} Cu^+ Tl^+	Ca^{2+} Sr^{2+} Ba^{2+} Ra^{2+} Pb^{2+} Ag^+	most	most	most

Using the Solubility Table:

ex) NaCl (aq)

1) Look for the non-metal on the top row.

2) Move down the chart to find the metal.

3) Move left to see the solubility.

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Solubility less than 0.1 mol/L (slightly soluble) (s)	none	none	Ag^+	Ag^+ Pb^{2+} Hg_2^{2+} Cu^+ Tl^+	Ca^{2+} Sr^{2+} Ba^{2+} Ra^{2+} Pb^{2+} Ag^+	most	most	most

ex) HgCl (s)

ex) Determine the solubility of each compound.

ex) NH_4F

ex) KNO_3

ex) $Ca(OH)_2$

ex) MgS

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Other hints for determining states:

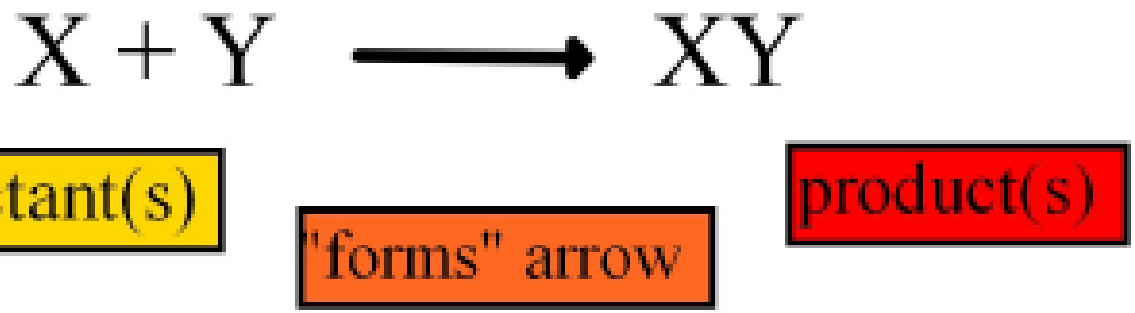
- Large molecular compounds are typically solids (think sucrose, $C_{12}H_{22}O_{11(s)}$), medium sized ones are liquid (ethanol, $C_2H_5OH_{(l)}$), small ones are gases (methane, $CH_{4(g)}$).

- Use common knowledge: many of the chemicals we deal with you have seen and used in your life or at least have some knowledge of (sugar, hydrogen peroxide, oils, etc).

- Practice practice practice: the more problems you do, the more compounds you'll encounter, and eventually you'll remember most of them (like me).

Chemical Equations

Chemists use equations to represent chemical reactions. A chemical reaction has three main parts:



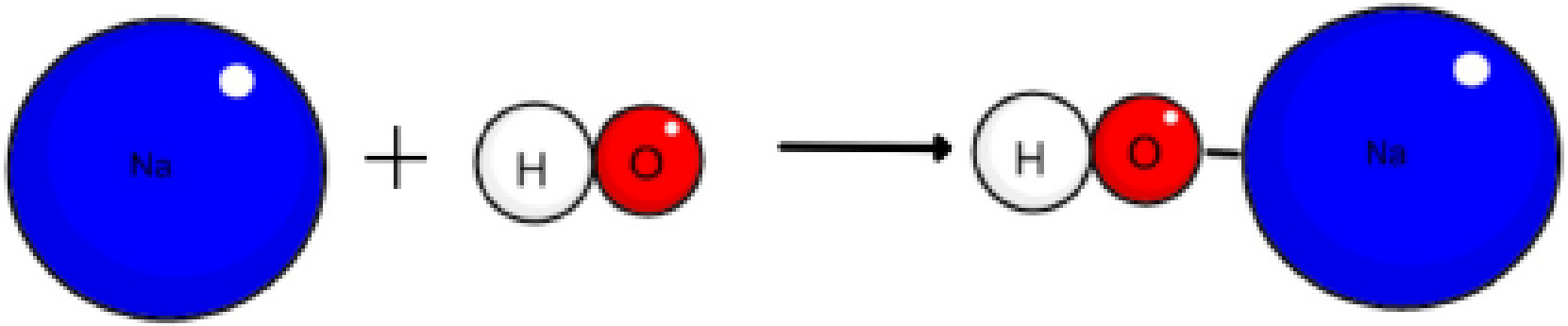
Properly written chemical equations obey the law of conservation of matter, which states:

Matter can not be created or destroyed, only changed in form.

Put another way, the amount of reactants must equal the amount of products in a chemical equation.

Let's investigate the law of conservation of matter in chemical equations. Here is a simple equation to create sodium hydroxide.

$$Na^{+} + OH^{-} \longrightarrow NaOH$$

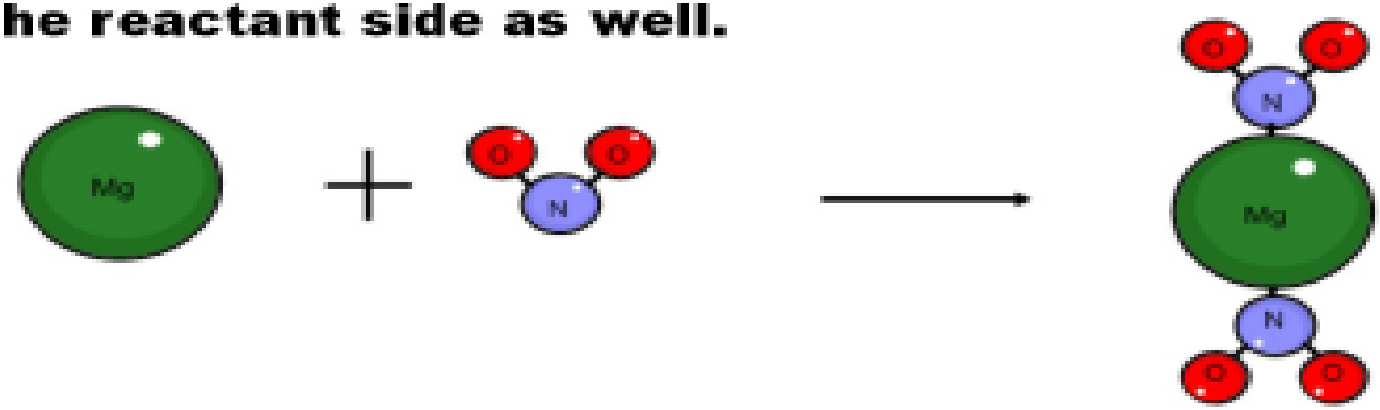


Note there are three atoms on the reactant side and three on the product side. The amount of matter before the reaction is equal to the amount after the reaction.

Let's look at another example, the reaction for magnesium nitrite.

$$Mg + NO_2 \longrightarrow Mg(NO_2)_2$$

There is one Mg and two NO_2 molecules on the product side. We must therefore have the same number of atoms on the reactant side as well.



We will now rewrite the equation in the correct balanced form.

$$Mg + 2NO_2 \longrightarrow Mg(NO_2)_2$$

The "2" in front of the nitrate molecule is a coefficient indicating there are two nitrate molecules on the reactant side.

In the last example, we balanced the equation to make the numbers of atoms the same on either side.

Let's try it again.

$$\_\_\ Mg + \_\_\ NO_2 \longrightarrow \_\_\ Mg(NO_2)_2$$

ex. Balance the equation.

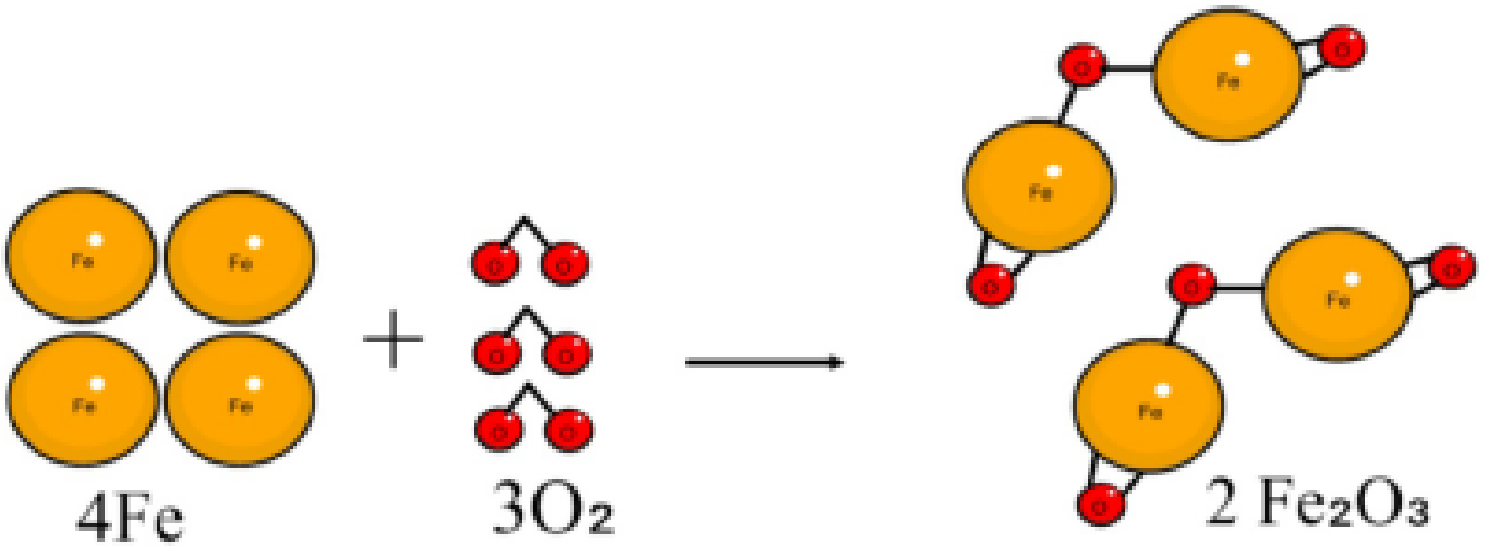
$$\_\_\ H_2 + \_\_\ O_2 \longrightarrow \_\_\_\ H_2O$$

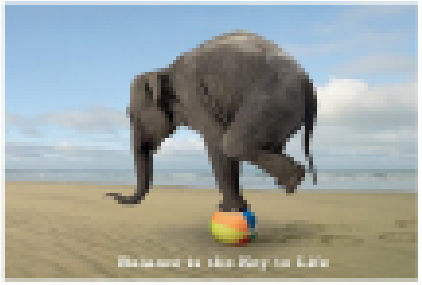
Let's look at the equation for iron (III) oxide.

$$Fe + O_2 \longrightarrow Fe_2O_3$$

This one is more difficult, because we have two O on the left and three O on the right. We have to find the common multiple between the two to balance the equation.

$$\_\_ Fe + \_\_ O_2 \longrightarrow \_\_\_ Fe_2O_3$$





Balancing Equations

When the equation is balanced, there will be the same number of each type of atom on each side of the arrow.

Balancing equations is easy if you follow a few steps:

ex) Balance the equation:

$$\_\_\ CuCl_2 + \_\_\ Fe \longrightarrow \_\_\ Cu + \_\_\ FeCl_3$$

Step 1: Make a list of all the atoms present

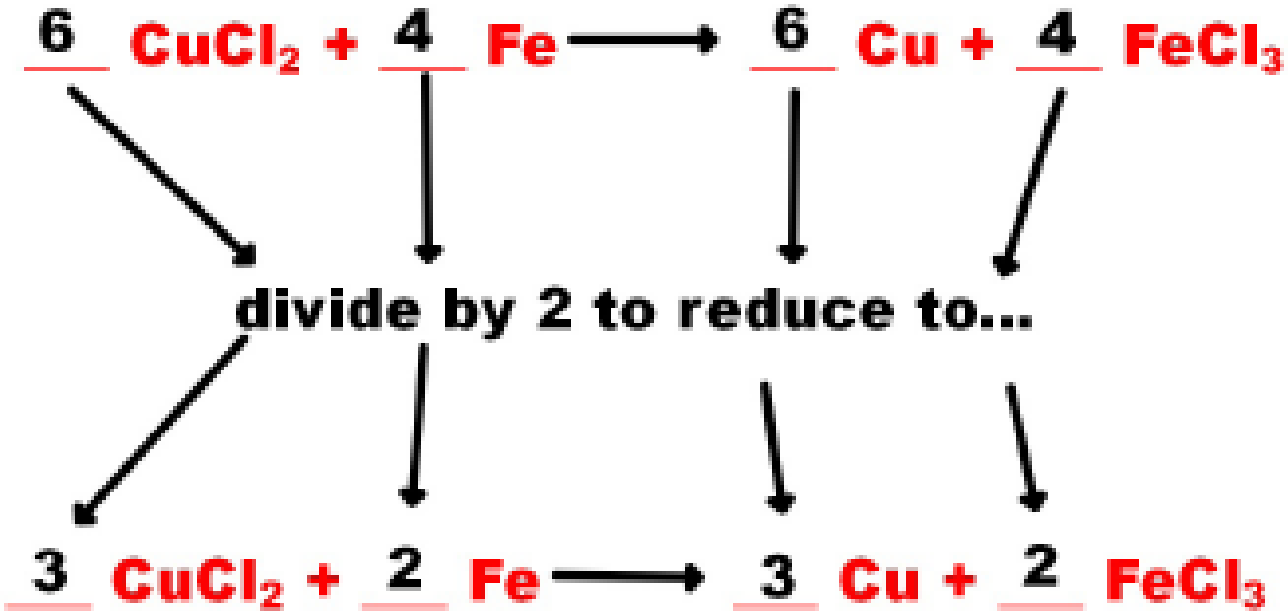
Cu - ____	Cu - ____
Cl - ____	Cl - ____
Fe - ____	Fe - ____

Step 2: Start to place numbers in front of the products and reactants. These numbers are called coefficients. Just try to balance one atom at a time.

HINT: Write in pencil and don't be afraid to do a little trial and error.

Note: When balancing, reduce the coefficients to the lowest whole number ratios possible.

ex) $6\ CuCl_2 + 4\ Fe \longrightarrow 6\ Cu + 4\ FeCl_3$



$3\ CuCl_2 + 2\ Fe \longrightarrow 3\ Cu + 2\ FeCl_3$

Notice the importance of being able to count atoms when balancing.

ex) How many of each type of atom is in each compound?

$Mg(OH)_2$ ← This 2 next to brackets means there are two O's and two H's

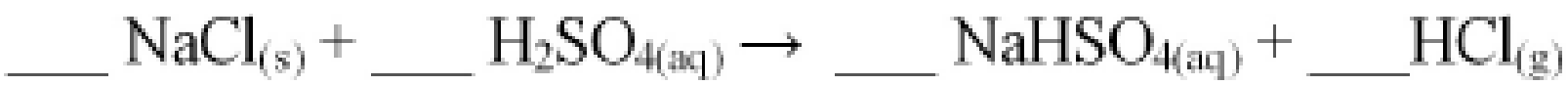
$Ca(NO_3)_2$ ← This 2 next to brackets means there are two NO_3's

This coefficient of 2 means that there are two Ca's and 2 x 2 = 4 NO_3's → $2Ca(NO_3)_2$

ex) Balance each equation (examples from workbook)

$$\_\_\_\_\_\ Cu_{(s)} + \_\_\_\_\_\ S_{(s)} \rightarrow \_\_\_\_\_\ Cu_2S_{(s)}$$

$$\_\_\_\_\_\ N_{2(g)} + \_\_\_\_\_\ H_{2(g)} \rightarrow \_\_\_\_\_\ NH_{3(g)}$$



***Note these compounds have states of matter (more on this later).**

Tips for balancing equations:

1) Work in pencil! You will often need to make changes to the coefficients you pick.

2) Keep polyatomic ions together and count as one atom (whenever possible)

3) Most equations will balance with relatively small numbers (1's and 2's and 3's normally).

Chemical Reactions

Signs of a chemical reaction:

- **Products are found to have a new composition**
- **Heat or light is given off**
- **Production of a gas (bubbles)**
- **Formation of a precipitate (solid that separates from a solution)**
- **Change in colour or odor**

Signs of a physical reaction:

- **Phase change (change of state)**
- **Change of texture, shape, size, volume, mass, weight, or density**

Types of Reactions

We study 5 main types of reactions:

1. Simple Composition (SC) or Formation (F). Two elements combine to form a compound.

ex. $2Na_{(s)} + Cl_{2(aq)} \longrightarrow 2NaCl_{(aq)}$

2. Simple Decomposition (SD): A compound decomposes into its two elements.

ex. $2HgO_{(s)} \longrightarrow 2Hg_{(l)} + O_{2(g)}$

3. Single Replacement (SR): An element and compound react to form a different element and compound.

ex. $Zn_{(s)} + Cu(NO_2)_{2(aq)} \longrightarrow Zn(NO_2)_{2(aq)} + Cu_{(aq)}$

4. Double Replacement (DR): Two compounds form two new compounds.

5. Hydrocarbon Combustion (HC): A hydrocarbon reacts with oxygen gas to form carbon dioxide gas and water vapor.

ex. $CH_{4(g)}$ + $2O_{2(g)}$ ⟶ $CO_{2(g)}$ + $2H_2O_{(g)}$

Any other reaction can be classified with an (O) for "other".

Practice: Balance the equations. Ignore the states of matter (for now). Indicate the type (SC, SD, SR, DR, HC, O) of reaction.

1) ___ C_3H_8 + ___ O_2 → ___ CO_2 + ___ H_2O

2) ___ Al + ___ Fe_3N_2 → ___ AlN + ___ Fe

3) ___ Na + ___ Cl_2 → ___ NaCl

4) ___ H_2O_2 → ___ H_2O + ___ O_2

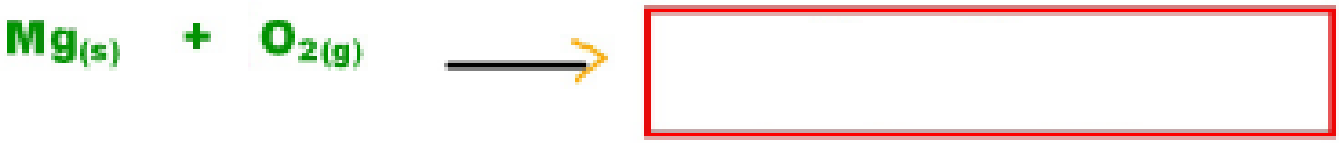
5) ___ $C_6H_{12}O_6$ + ___ O_2 → ___ H_2O + ___ CO_2

6) ___ H_2O + ___ CO_2 → ___ C_7H_8 + ___ O_2

7) ___ $NaClO_3$ → ___ $NaCl$ + ___ O_2

Writing equations when only one side is known.

Knowing the five basic types of reactions will help you predict unknown products of reactions. For example;



What is the product(s) here?

1.) Determine the type of reaction (SC, SD, DR, etc)
2.) Write products (cross charges, reduce)
3.) State (solubility table)
4.) Balance

Look at the reactants. Two elements. When two elements react, we get a simple composition.

$$Mg_{(s)} + O_{2(g)} \_\_\_\_\_ MgO_{(s)}$$

Then balance.

$$2\ Mg_{(s)} + O_{2(g)} \_\_\_\_\_ 2\ MgO_{(s)}$$