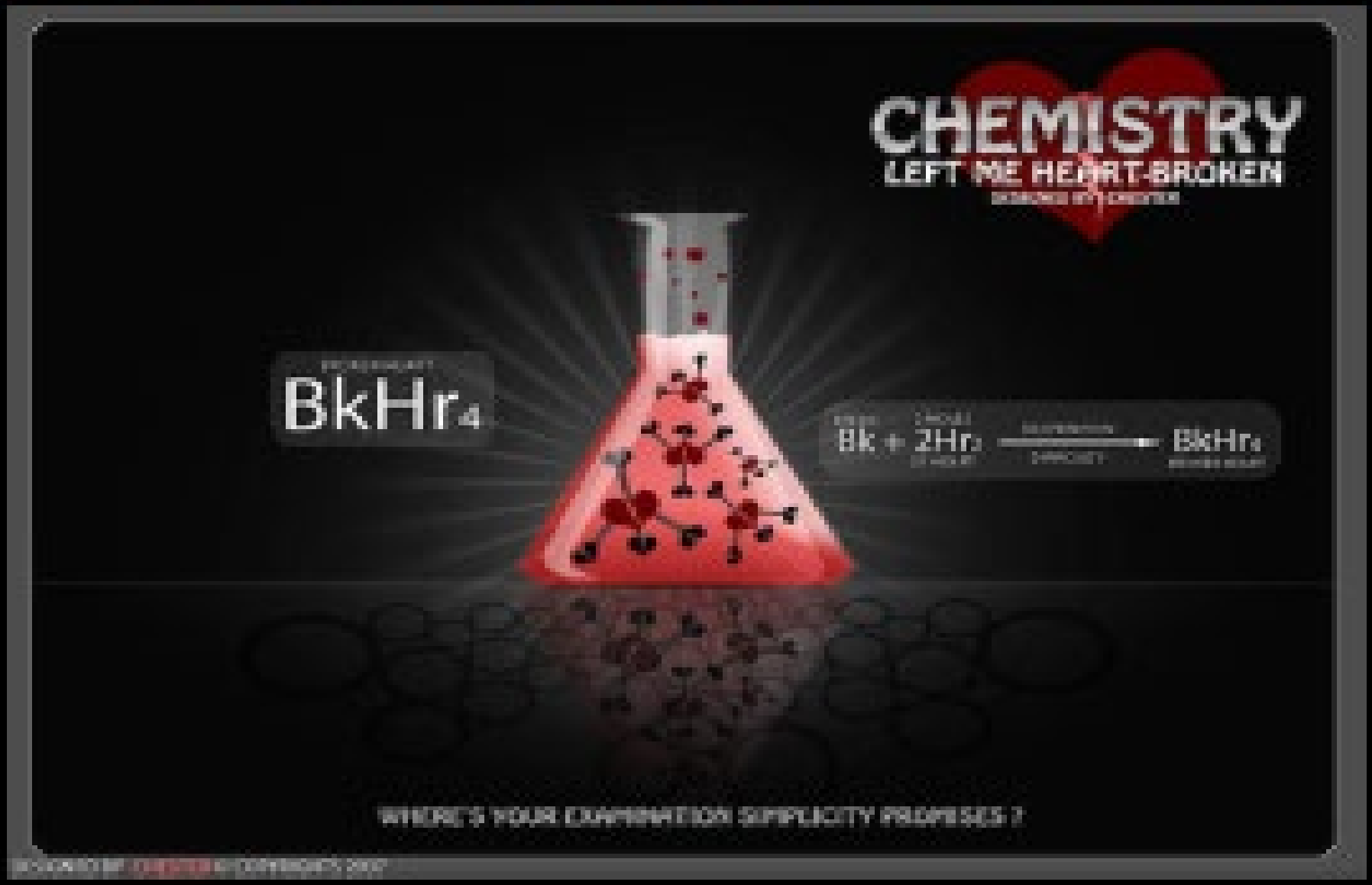
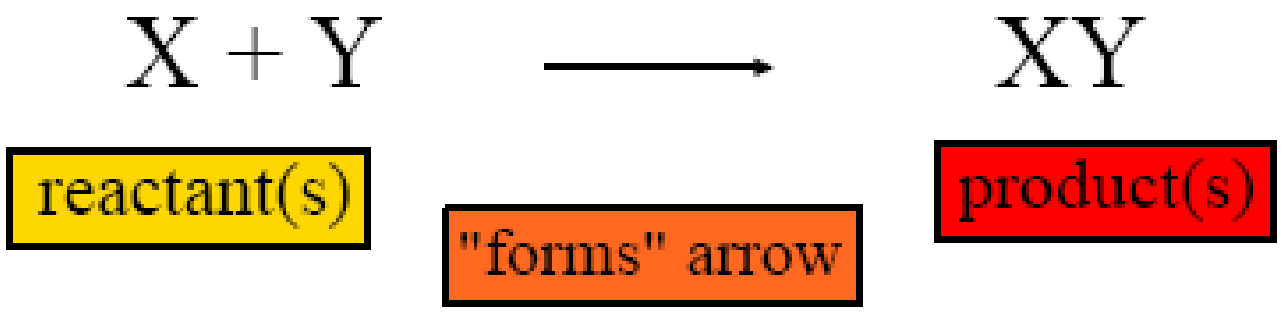
Writing Chemical Equations



Chemical Equations

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



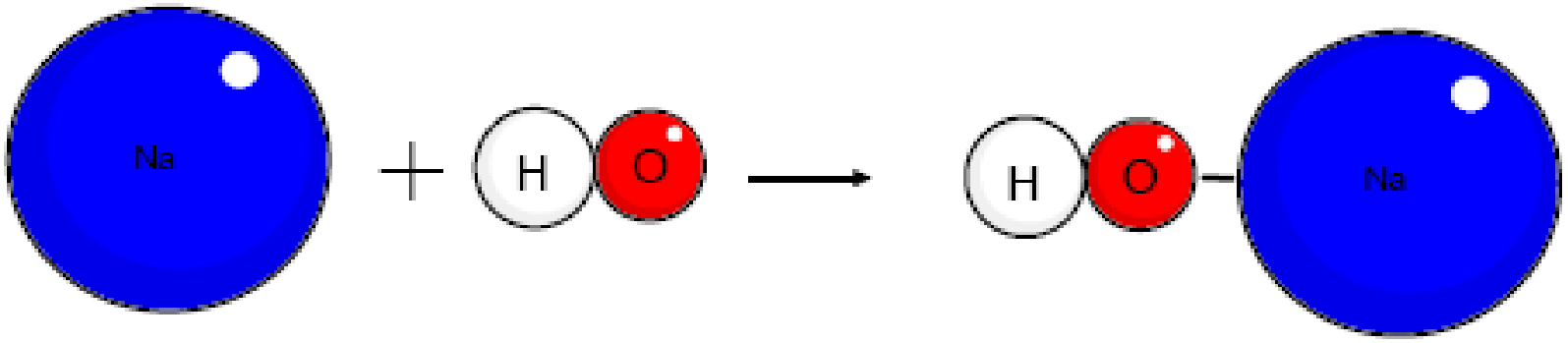
Properly written chemical equations obey the law of conservation of matter, which states:

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.

$$Na + OH \longrightarrow NaOH$$

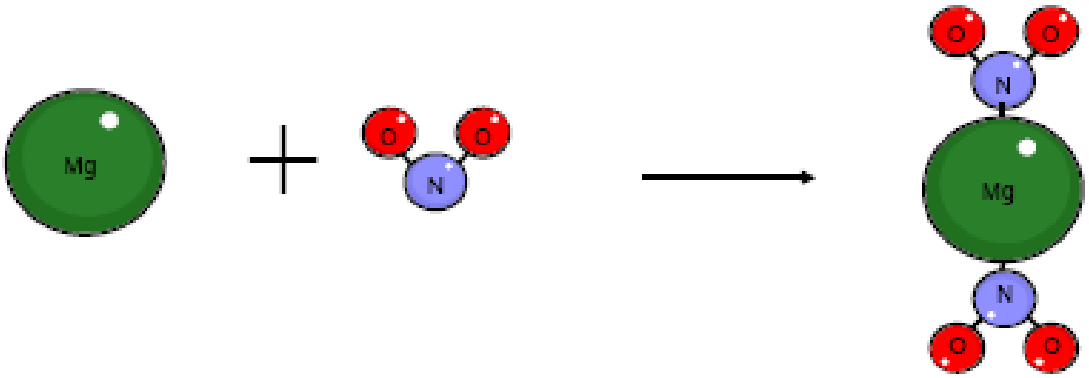


Note there are three atoms on the reactant side and three on the product side. The amount of matter before the reaction is equal to the amount after the reaction.

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

$$Mg + NO \longrightarrow Mg(NO\ )$$

There is one Mg and two NO 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.

$$Mg + 2NO \longrightarrow Mg(NO\ )$$

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.

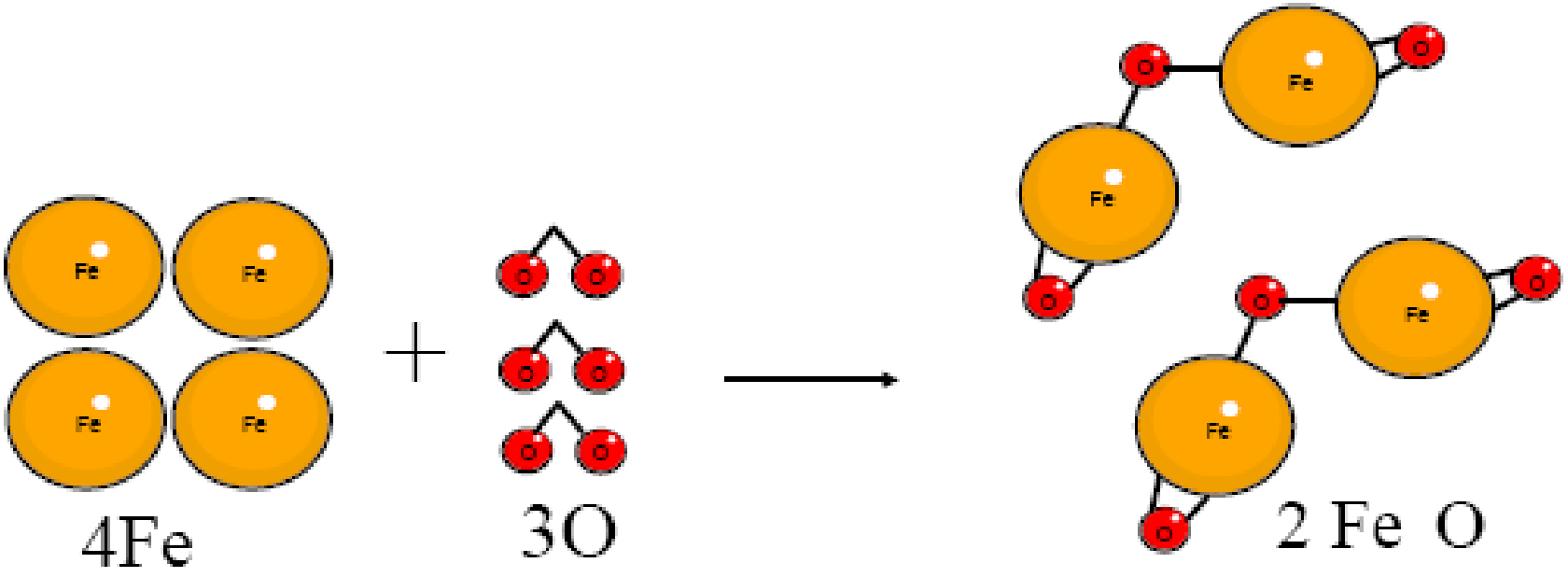
ex. Balance the equation.

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

$$Fe + O \longrightarrow Fe\,O$$

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.

$$\_\_\_\,Fe + \_\_\_\,O \longrightarrow \_\_\_\_\,Fe\,O$$




___ Fe + ___ O ⟶ ____ Fe O

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	SUBSCRIPT
solid	(s)
liquid	(l)
gas	(g)
aqueous	(aq)

From now on, we will write the states of matter into our equations. The states for elements are given on the periodic table. The states for compounds can be determined either using a solubility table (ionic compounds) or by molecule size (molecular compounds).

The Solubility Table

Solubility of Some Common Ionic Compounds in Water at 298.15 K

Ion	Group 1 NH_4^+ H_3O^+ (H^+)	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^+ Hg^+	Ag^+ Pb^{2+} Hg^+ Cu^+ Tl^+	Ca^{2+} Sr^{2+} Ba^{2+} Ra^{2+} Pb^{2+} Ag^+	most	most	most

very soluble = aq

slightly soluble = s

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

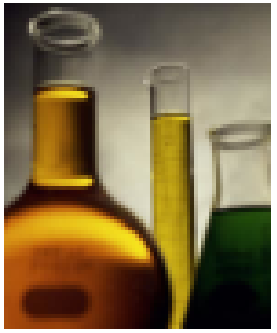
Other hints for determining states:

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

- 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 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.

ex. $HCl_{(aq)} + NaOH_{(aq)} \longrightarrow NaCl_{(aq)} + H_2O_{(l)}$

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

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

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

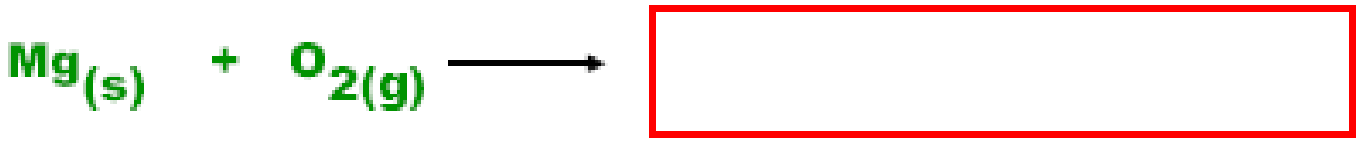
5) ___ $C_6H_{12}O_6$ + ___ O_2 → ___ H_2O + ___ CO_2

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

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

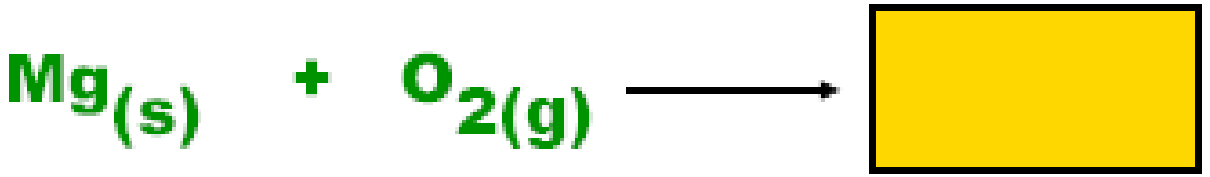
Writing equations when only one side is known.

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

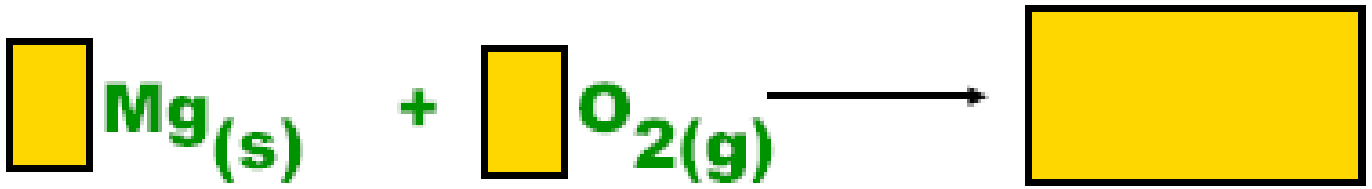


What is the product(s) here?

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



Then balance.



ex) Determine the product and balance.