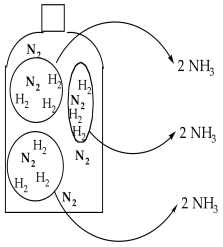
Activity Online: Writing And Balancing Chemical Equations

Objective: The purpose of this activity is to become familiar in writing and balancing chemical equations. Chemical equations will be written and balanced from given either the chemical names or the chemical formulas. Molecular equations, complete ionic equations, and net ionic equations will also be solved for double displacement type of reactions.

Discussion: The heart of chemistry is the chemical reaction which portrays how new compounds form. The basis of a chemical reaction is the "Law of conservation of mass". That is the total atoms of the reactant is equal to the total atoms of the product. The general form of a chemical reaction is illustrated as: Reactant $\xrightarrow{\text{yield}}$ Product.

Consider the reaction between molecular nitrogen and molecular oxygen. This is shown below.

Chemical Reaction:



$9\ H_2 + 6\ N_2 \rightarrow 6\ NH_3 + 3N_2$ (excess)

atoms reactant = atoms product

The net molecular equation is:

$9\ H_2\ (g) + 3\ N_2\ (g) \rightarrow 6\ NH_3\ (g)$

Note: 18 H and 6 N in each side!!

In general a chemical reaction can be expressed as:

$a\ A + b\ B \rightarrow c\ C + d\ D$

where a, b - coefficient of reactant (how many).

c, d - coefficient of product (how many).

atoms (reactant) = # atoms product : Balance

Example # 1: Combination reaction between magnesium metal and molecular oxygen.

First write the correct formula of each chemical-

$Mg + O_2 \rightarrow MgO$

↑Oxygen from air ↓Product

To balance:

$Mg + O_2 \rightarrow MgO_2$ No!! (never since MgO_2 is different from MgO)

$Mg + O_2 \rightarrow 2MgO$ Oxygen is now okay but Mg is now not balance

$2\ Mg + O_2 \rightarrow 2MgO$ Now oxygen okay and Mg okay.

↑Coefficient ↑Subscript

Example #2: Decomposition reaction of H_2O

$H_2O \rightarrow H_2 + O_2$

2H ↑ ↑1 O 2H ↑ ↑2 O

Chemicals are identified, but oxygen is not balanced.

H_2O_2 ?

Change H_2O to H_2O_2 ? No! Since now the identity has changed.

Can only change coefficient when balancing a reaction.

2 $H_2O \rightarrow H_2 + O_2$

Change coefficient of waters (H_2O) to **2**

4H 2O 2 H 2 O

Oxygens are balanced but now hydrogens are not.

$2\ H_2O \rightarrow$ **2** $H_2 + O_2$

Balanced by changing coefficient in front of H_2 to **2**

4H 2O 4H 2O

2 O's, and now 4 H's, in each side of equation.

$2\ H_2O \rightarrow 2\ H_2 + O_2$

The equation is now balance !!!

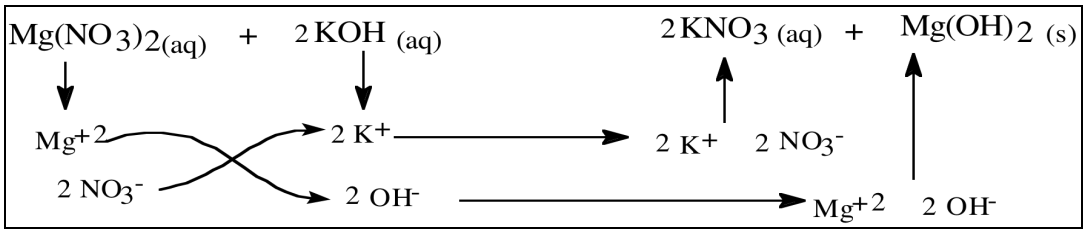
Summary: Balancing chemical reaction

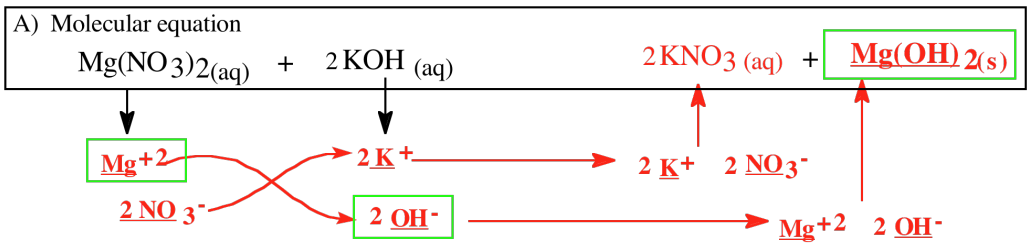
- Once chemical formula of species is determined you can never change the subscript of the chemical.
- To start, assign a coefficient of 1 (one) to most complicated chemicals.
- Balance the homogeneous atomic molecules last i.e., H_2, N_2, O_2.
- Balance cation/anion as a single unit (i.e., if occurs in reactant and product unchanged)
- Convert the fraction coefficients to integers.

Example # 3: Balancing a double displacement (metathesis)

Consider the reaction: $Mg(NO_3)_2$ + KOH → Products

What are the products formed and how can the equation be balanced?





B) Complete ionic equaiton

C) Net ionic equaiton

3 ways of writing the chemical reaction for a double displacement reaction:

a) **Molecular equation**: This is an equation showing the overall reaction stoichiometry. The chemicals in the reaction are all shown in their neutral form.

b) **Complete ionic equation**: This is an equation shows ions that are strong electrolytes. The chemicals are shown as they would exist in aqueous medium. The ions are shown as ions and precipitates or weak electrolytes shown as neutral formulas.

c) **Net ionic equation**: This is an equation shows only substances undergoing chemical changes. The ions involved in the formation of product are shown in this equation. Spectator ions are left out of the equation.

Summary:

a) Molecular equation:

$$Mg(NO_3)_{2(aq)} + 2KOH_{(aq)} \rightarrow 2KNO_{3(aq)} + Mg(OH)_{2\,(s)}$$

b) Complete ionic equation:

$$Mg^{2+}_{(aq)} + 2\,NO_3^-{}_{(aq)} + 2\,K^+_{(aq)} + 2\,OH^-_{(aq)} \rightarrow 2\,K^+_{(aq)} + 2\,NO_3^-{}_{(aq)} + Mg(OH)_{2\,(s)}$$

c) Net ionic equation:

$$Mg^{2+}_{(aq)} + 2\,OH^-_{(aq)} \rightarrow Mg(OH)_{2\,(s)}$$

Example # 4: Balancing a neutralization reaction is a form of double displacement reaction.

$$\_\_HNO_{3\,(aq)} + \_\_Ca(OH)_{2\,(aq)} \rightarrow \_\_H_2O_{\,(l)} + \_\_Ca(NO_3)_{2\,(aq)}$$

Information about reactants

Acids - provides H^+

Base - provides OH^-

acid in water; at a molecular level. - (Aqueous chemistry)

Information about products

Water (a weak electrolyte) and a salt (ionic compound) are produced in an acid-base reaction.

salt : (cation - anion)

Balanced Equation: $2\,HNO_{3\,(aq)} + 1\,Ca(OH)_{2\,(aq)} \rightarrow 2\,H_2O_{\,(l)} + 1\,Ca(NO_3)_{2\,(aq)}$

Table A9.1 Solubility Rules. The table indicates the precipitate form in aqueous solution.

Soluble Substances		**Insoluble Substances**	
Containing-	***Exceptions***	***Containing-***	***Exceptions***
Nitrates (NO_3^-) Perchlorates (ClO_4^-) Acetates (CH_3CO_2-) Chlorates (ClO_3^-)	**None**	Carbonates (CO_3^{2-}) Chromates (CrO_4^{2-}) Phosphates (PO_4^{3-}) Sulfides (S^{2-})	**Alkali and NH_4+**
Halogens (X-) Cl^- , Br^-, I-	**Ag, Hg & Pb.**	Hydroxides (OH^-)	**Ca, Ba, Sr, Alkali & NH_4^+**
Sulfates (SO_4^{2-})	**Ca, Ba, Hg and Pb**	**Soluble - dissolve, no precipitate (aq -phase) insoluble (or slightly sol.) - does not dissolve, precipitate forms. (s-phase)**	
Alkali (Group1A) NH_4^+	**None**		

Try the following as an exercise.

#1 Sodium oxide and water forms sodium hydroxide

#2 Ferric(III) Sulfide & molecular oxygen yields ferric(III) oxide & sulfur dioxide.

#3 C_4H_{10} (g) + O_2 (g) → H_2O(g) + CO_2 (g) (combustion)

In a *combustion* reaction, water, CO_2 and energy are always produced.

#4 H_2SO_4 (aq) + $Ca(OH)_2$ (aq) → $H_2O_{(l)}$ + $CaSO_4$ (s)

Table A9.2 Classifications of Chemical Reactions

1. Combination Reaction

A + B → AB

Example:

i) __ SO_3 + __ H_2O → __ H_2SO_4

ii) __ Cu + __ O_2 → __ CuO

iii) __ N_2 + __ H_2 → __ NH_3

2. Decomposition Reaction

AB → A + B

Example:

i) __ H_2CO_3 → __ H_2O + __ CO_2

ii) __ $KClO_3$ → __ KCl + __ O_2

3. Single Displacement Reaction:

A + BC → AC + B

Example:

i) __ Zn + __ $Cu(NO_3)_2$ → __ $Zn(NO_3)_2$ + __ Cu

ii) __ Ca + __ H_2O → __ $Ca(OH)_2$ + __ H_2

iii) __ Mg + __ HCl → __ $MgCl_2$ + __ H_2

4a. Double Displacement Reaction:

AB + CD → AD + CB

Example:

i) __ $Ba(NO_3)_2$ + __ H_2S → __ BaS + __ HNO_3

ii) __ $MgCl_2$ + __ Na_3PO_4 → __ $Mg_3(PO_4)_2$ + __ NaCl

iii) __ $HC_2H_3O_2$ + __ $NaHCO_3$ → __ $NaC_2H_3O_2$+ __ H_2CO_3

4b. Acid Base (Double Displacement) Reaction:

HA + MOH → H_2O + MA

Example:

i) __ HNO_3 + __ $Ba(OH)_2$ → __ H_2O + __ $Ba(NO_3)_2$

ii) __ HCl + __ NH_4OH → __ H_2O + __ NH_4Cl

5. Combustion Reaction

CxHy + O_2 → CO_2 + H_2O

Example:

i) __ C_4H_{10} + __ O_2 → __ CO_2 + __ H_2O

ii) __ $C_{12}H_{22}O_{11}$ + __ O_2 → __ CO_2 + __ H_2O

iii) __ C_2H_5OH + __ O_2 → __ CO_2 + __ H_2O

WWW Links to balancing chemical reactions (Accessed Jun 2011)

1. http://www.webqc.org/balance.php
2. http://misterguch.brinkster.net/eqnbalance.html
3. http://www.youtube.com/watch?v=RnGu3xO2h74
4. http://www.schooltube.com/video/db41eba5cdbd45fcbe75/Balancing-Chemical-Equations
5. http://www.chemtutor.com/react.htm
6. http://antoine.frostburg.edu/chem/senese/101/reactions/faq/predicting-products-nicl2-nh42s.shtml

Classifications of Chemical Reactions

1. Combination Reaction

$A + B \rightarrow AB$

Example:

i) $\_\_ SO_3 + \_\_ H_2O \rightarrow \_\_ H_2SO_4$

ii) $\_\_ P + \_\_ S \rightarrow \_\_ P_2S_5$

iii) $\_\_ N_2 + \_\_ H_2 \rightarrow \_\_ NH_3$

2. Decomposition Reaction

$AB \rightarrow A + B$

Example:

i) $\_\_ H_2CO_3 \rightarrow \_\_ H_2O + \_\_ CO_2$

ii) $\_\_ KClO_3 \rightarrow \_\_ KCl + \_\_ O_2$

3. Single Displacement Reaction:

$A + BC \rightarrow AC + B$

Example:

i) $\_\_ Zn + \_\_ Cu(NO_3)_2 \rightarrow \_\_ Zn(NO_3)_2 + \_\_ Cu$

ii) $\_\_ Ca + \_\_ H_2O \rightarrow \_\_ Ca(OH)_2 + \_\_ H_2$

4a. Double Displacement Reaction:

$AB + CD \rightarrow AD + CB$

Example:

i) $\_\_ Ba(NO_3)_2 + \_\_ H_2S \rightarrow \_\_ BaS + \_\_ HNO_3$

ii) $\_\_ MgCl_2 + \_\_ Na_3PO_4 \rightarrow \_\_ Mg_3(PO_4)_2 + \_\_ NaCl$

4b. Acid Base (Double Displacement) Reaction:

$HA + MOH \rightarrow H_2O + MA$

Example:

i) $\_\_ HNO_3 + \_\_ Ba(OH)_2 \rightarrow \_\_ H_2O + \_\_ Ba(NO_3)_2$

ii) $\_\_ HCl + \_\_ NH_4OH \rightarrow \_\_ H_2O + \_\_ NH_4Cl$

5. Combustion Reaction

$CxHy + O_2 \rightarrow CO_2 + H_2O$

Example:

i) $\_\_ C_4H_{10} + \_\_ O_2 \rightarrow \_\_ CO_2 + \_\_ H_2O$

ii) $\_\_ C_6H_{12}O_6 + \_\_ O_2 \rightarrow \_\_ CO_2 + \_\_ H_2O$

WWW Links to balancing chemical reactions (Accessed Jan 2011)

1. http://richardbowles.tripod.com/chemistry/balance.htm
2. http://www.webqc.org/balance.php
3. http://misterguch.brinkster.net/eqnbalance.html
4. http://www.youtube.com/watch?v=RnGu3xO2h74
5. http://www.chemtutor.com/react.htm
6. http://antoine.frostburg.edu/chem/senese/101/reactions/faq/predicting-products-nicl2-nh42s.shtml

Activity Online: Writing And Balancing Chemical Equations

____ / ___ **Score** **Last Name** _____**First**_____ Date _____

A. Balance the following equations:

Example: $\underline{2}\,H_{2(g)} + \underline{1}\,O_{2(g)} \xrightarrow{\Delta} \underline{2}\,H_2O_{(g)}$ Sum of coefficient = 2 + 1 + 2 = 5

1. $\_CaO_{(s)} + \_CO_{2\,(g)} \longrightarrow \_CaCO_{3\,(s)}$ The sum of the coefficient equals ____

2. $\_\_KIO_{3\,(s)} \xrightarrow{\Delta} \_\_KI_{(s)} + \_\_O_{2(g)}$ The sum of the coefficient equals ____

3. $\_\_Fe_{(s)} + \_\_S_{2(g)} \xrightarrow{\Delta} \_\_Fe_3S_{4(s)}$ The sum of the coefficient equals ____

4. $\_\_Mg_{(s)} + \_\_HBr_{(aq)} \rightarrow \_\_MgBr_{2\,(aq)} + \_\_H_{2\,(g)}$ The sum of the coefficient equals ____

B. Complete and balance the following double displacement rxn equations (assume all reactions goes to completion):

1. $\_\_KCl_{(aq)} + \_\_AgNO_{3\,(aq)} \rightarrow$ The sum of the coefficient equals ____

2. $\_\_SrCl_{2\,(aq)} + \_\_H_2SO_{4\,(aq)} \rightarrow$ The sum of the coefficient equals ____

3. $\_KOH_{(aq)} + \_HCl_{(aq)} \rightarrow$ The sum of the coefficient equals ____

4. $\_Na_2CO_{3\,(s)} + \_HCl_{(s)} \rightarrow$ The sum of the coefficient equals ____

C. Complete and balance (Combination, Decomposition, Single displacement, Double displacement)

1. $\_\,K(s) + \_\,Cl_2\,(g) \rightarrow$
   The sum of the coefficient equals ____
   (potassium chloride)

2. $\_\,Zn\,(s) + \_\,O_2\,(g) \rightarrow$
   The sum of the coefficient equals ____
   (zinc oxide)

3. $\_\,BaO\,(s) + \_\,H_2O(l) \rightarrow$
   The sum of the coefficient equals ____
   (barium hydroxide)

4. $\_\,SO_3(g) + \_H_2O(l) \rightarrow$
   The sum of the coefficient equals ____
   (sulfuric acid)

5. $\_\,Ni\,(s) + \_\,HCl\,(aq) \rightarrow$
   The sum of the coefficient equals ____
   (nickel(II)chloride and hydrogen)

6. $\_\,Pb\,(s) + \_\,AgNO_3\,(aq) \rightarrow$
   The sum of the coefficient equals ____
   (lead(II)nitrate and silver)

7. $\_\,(NH_4)_2SO_4\,(aq) + \_\,KOH\,(aq) \rightarrow$
   The sum of the coefficient equals ____
   (ammonium hydroxide and potassium sulfate)

8. $\_\,ZnCl_2\,(aq) + \_\,(NH_4)_2S\,(aq) \rightarrow$
   The sum of the coefficient equals ____
   (zinc sulfide and ammonium chloride)

D. Beneath each word equation write the formula equation and balance it.

Be sure to write the correct formula for those elements that exist as diatomic molecules:

1. Sulfur dioxide $_{(g)}$ + Oxygen $_{(g)}$ $\xrightarrow{\Delta}$ Sulfur trioxide $_{(g)}$ Sum coefficient: _____

2. Zinc $_{(s)}$ + Sulfuric acid $_{(aq)}$ → Zinc sulfate $_{(aq)}$ + Hydrogen $_{(g)}$ Sum coefficient: _____

3. Ammonia $_{(g)}$ + oxygen $_{(g)}$ $\xrightarrow{\Delta}$ water $_{(g)}$ + nitrogen monoxide $_{(g)}$ Sum coefficient: _____

4. Ammonium nitrate $_{(s)}$ $\xrightarrow{\Delta}$ Nitrogen $_{(g)}$ + Oxygen $_{(g)}$ + Water $_{(g)}$ Sum coefficient: _____

5. Sodium bicarbonate $_{(s)}$ $\xrightarrow{\Delta}$ sodium carbonate $_{(s)}$ + carbon dioxide $_{(g)}$ + dihydrogen monoxide $_{(g)}$

Sum coefficient: _____

6. nitrogen dioxide $_{(g)}$ + dihydrogen monoxide $_{(l)}$ → nitric acid $_{(g)}$ + nitrogen monoxide $_{(g)}$

Sum coefficient: _____