Ch. 10.1 chemical equations

example: photosynthesis

$CO_{2\,(g)} + H_2O_{(g)} \rightarrow C_6H_{12}O_{6\,(aq)} + O_{2\,(g)}$

- uses chemical formulas to identify the chemicals in a chemical reaction
- may identify the "state / phase" of the chemical using parenthesis
  - l = liquid
  - g = gas
  - s = solid
  - aq = aqueous = dissolved in water
- reactant(s) → product(s)
  - reactant(s) = chemical(s) at the "beginning" of a reaction
  - product(s) = chemical(s) at the "end" of a reaction
  - → = "to form"

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review: chemical formulas

- $Mg(NO_3)_2$ = Mg & NO_3 & NO_3 has 1-Mg, 2-N, and 6-O

coefficients in a chemical equation

- number in front of chemical formula in a chemical equation
- represents the number of molecules in the chemical equation
- example: 3 $Ca(NO_3)_{2(aq)}$ + 2 $Na_3PO_{4(aq)}$ → $Ca_3(PO4)_{2(s)}$ + 6 $NaNO_{3(aq)}$
  - if there's no number, then the value of the coefficient = 1
  - i.e. 3 molecules of $Ca(NO_3)_2$ reacts with 2 molecules of Na_3PO_4 to form 1 molecule of $Ca_3(PO4)_2$ and 6 molecules of $NaNO_3$

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continue – coefficients in a chemical equation

- $2\ H_2O = H_2O + H_2O$
  where there are
  - 4 atoms of hydrogen and
  - 2 atoms of oxygen

- $3\ Ca(NO_3)_2 = Ca(NO_3)_2 + Ca(NO_3)_2 + Ca(NO_3)_2$
  where there are
  - 3 atoms of Ca
  - 6 atoms of N
  - 18 atoms of O (oxygen)

  since 1 molecule of $Ca(NO_3)_2$ has 1 – Ca, 2 – N, and 6 – O

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"balance" a chemical equation

- satisfies the conservation of mass
  - i.e. no atom is created nor destroyed in a chemical reaction
  - i.e. start and end with the same number of atoms in a reaction
- use the lowest ratio of integer coefficients to satisfy the conservation of mass

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examples: balance the following chemical equations

ex1. $H_2 + O_2 \rightarrow H_2O$

H: 2 2

O: 2 1

H is ok, but destroyed O, so need more O as a product

$H_2 + O_2 \rightarrow 2\ H_2O$

H: 2 4

O: 2 2

but now, the H is created, i.e. it's not balanced, so need more H

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

H: 4 4

O: 2 2

ok; it's "balanced" and used the lowest ratio of integer coefficients

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continue - ex 2

$N_2 + H_2 \rightarrow NH_3$

N: 2 1

H: 2 3

need more N as product and more H as reactant, so let's balance N, since its cleaner

$N_2 + H_2 \rightarrow 2\ NH_3$

N: 2 2

H: 2 6

now, let's balance H as reactant

$N_2 + 3\ H_2 \rightarrow 2\ NH_3$

N: 2 2

H: 6 6

ok; it's "balanced" and used the lowest ratio of integer coefficients

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continue – ex. 3; balance X_2 last, since "easy" to balance

ex3. $CH_3CH_3 + O_2 \rightarrow CO_2 + H_2O$

it's the same as: $C_2H_6 + O_2 \rightarrow CO_2 + H_2O$

C: 2 1

H: 6 2

O: 2 2 + 1 = 3

need more C on product, H on product, and O on reactant, so balance C & H

$C_2H_6 + O_2 \rightarrow 2\ CO_2 + 3\ H_2O$

C: 2 2

H: 6 6

O: 2 4 + 3 = 7

C and H are fine, but need more O on reactant side

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finish-up – ex 3

lastly, balance O by having more O on reactant side

$C_2H_6 + 3\frac{1}{2}\ O_2 \rightarrow 2\ CO_2 + 3\ H_2O$

C: 2 2

H: 6 6

O: 7 4 + 3 = 7 ; note: $3\frac{1}{2}\ O_2 = (3+\frac{1}{2})\ O_2 = 3\ O_2 + \frac{1}{2}\ O_2 = 6 + 1 = 7$ oxygen

while it's balanced, want lowest ratio of integers, so double the coefficients

$2\ C_2H_6 + 7\ O_2 \rightarrow 4\ CO_2 + 6\ H_2O$; note: $3\frac{1}{2} = \frac{7}{2}$

C: 4 4

H: 12 12

O: 14 8 + 6 = 14

ok; it's "balanced" and used the lowest ratio of integer coefficients

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ex. 4

$CH_3(CH_2)_2OH + O_2 \rightarrow CO_2 + H_2O$

"simplify": $C_3H_8O + O_2 \rightarrow CO_2 + H_2O$

C:	3	1
H:	8	2
O:	1 + 2 = 3	2 + 1 = 3

need more C on product and H on product

$C_3H_8O + O_2 \rightarrow 3\ CO_2 + 4\ H_2O$

C:	3	3
H:	8	8
O:	1 + 2 = 3	6 + 4 = 10

need more O on reactant,

$C_3H_8O + 4\ \frac{1}{2}\ O_2 \rightarrow 3\ CO_2 + 4\ H_2O$

double coefficients to get lowest ratio of integer coefficients

$2\ C_3H_8O + 9\ O_2 \rightarrow 6\ CO_2 + 8\ H_2O$

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ex 5. balance chem eqn with ionic compounds

aside: don't balance atoms, balance ions

$Ca(NO_3)_2 + K_3PO_4 \rightarrow KNO_3 + Ca_3(PO_4)_2$

Ca^{2+}:	1	3
NO_3^-:	2	1
K^+:	3	1
PO_4^{-3}:	1	2

let's balance the Ca^{2+} and PO_4^{-3}

$3\ Ca(NO_3)_2 + 2\ K_3PO_4 \rightarrow KNO_3 + Ca_3(PO_4)_2$

Ca^{2+}:	3	3
NO_3^-:	6	1
K^+:	6	1
PO_4^{-3}:	2	2

let's balance the K^+ and NO_3^-

$3\ Ca(NO_3)_2 + 2\ K_3PO_4 \rightarrow 6\ KNO_3 + Ca_3(PO_4)_2$ ----- it's balanced

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