Read Sections 5.1 and 5.2 before viewing the slide show.
Unit 17
Chemical Equations

• Writing Chemical Equations
• Balancing Chemical Equations
• Volume Relationships from Chemical Equations
Writing Chemical Equations (5.1)

• Verbal descriptions of what happens during a chemical reaction can become quite complex, thus a shorthand notation is desirable
• The use of chemical formulas greatly simplifies the expressions that are used to describe chemical changes
• Prior to exploring the shorthand notation, a note about the identification of diatomic elements is in order
There is an important set of seven diatomic elements that occur in nature.

Diatomic means that, as elements, they exist as two atoms bonded to each other. The seven diatomic elements are indicated in the periodic chart with a black border—notice how they sort of form the number “7”.

In formula form, the seven are $H_2$, $N_2$, $O_2$, $F_2$, $Cl_2$, $Br_2$, and $I_2$.

These are gases under normal conditions except for $Br_2$ which is liquid and $I_2$ which is solid.
Writing Chemical Equations (5.1)

• Consider the following statement:
  • Sodium solid and chlorine react to form solid sodium chloride

• The statement can be abbreviated somewhat by using chemical formulas in place of words (recall that Cl\textsubscript{2} is diatomic):
  • Na solid and Cl\textsubscript{2} gas react to form solid NaCl

• To streamline even more, the physical states of the substances involved may be represented by using the symbols (s) for solid, (l) for liquid, (g) for gas, and (aq) for a water-based solution. Then:
  • Na(s) and Cl\textsubscript{2} (g) react to form NaCl(s)

• And, to finally get rid of the words altogether, replace the and by a “+” and the react to form by “→”.
  • Na(s) + Cl\textsubscript{2} (g) → NaCl (s)

• This equation is not quite done, but it is now in symbolic form. Notice the number of Cl atoms is different on the left-hand side and the right-hand side – atoms are always conserved in a chemical change so that will need to be fixed.
Balancing Chemical Equations (5.1)

• The equation from the previous slide is:

\[
\text{Na}(s) + \text{Cl}_2 (g) \rightarrow \text{NaCl} (s)
\]

• Substances to the left of the arrow are called \textit{reactants} and those to the right \textit{products}.

• The reactant side contains 1 Na atom and 2 Cl atoms, while the product side contains 1 Na atom and 1 Cl atom. Atoms are not created or destroyed during a chemical change, so the equation will have to be “balanced” to ensure the numbers of atoms of each kind are the same on each side.

• Balancing is done by placing coefficients in front of the chemical substances as needed – the subscripts are never changed.

• Placing a 2 in front of NaCl will give two Cl atoms, but also gives 2 Na atoms. To get 2 Na atoms on the left, place a two in front of Na as well. The balanced equation becomes:

\[
2 \text{Na}(s) + \text{Cl}_2 (g) \rightarrow 2 \text{NaCl} (s)
\]
Gay-Lussac’s Law of Combining Volumes (5.2)

• In the 1700’s Joseph Louis Gay-Lussac proposed the law of combining volumes:
  • When all measurements are made at the same temperature and pressure, the volume of gaseous reactants and products are in a small whole number ratio.
• As an example, consider the reaction

\[
2 \text{H}_2(g) + \text{O}_2(g) \rightarrow 2 \text{H}_2\text{O}(g)
\]

• The balanced equation says that 2 molecules of hydrogen react with one molecule of oxygen to form 2 molecules of water. Molecules are pretty small – we only see the reaction with massive numbers of hydrogen and oxygen molecules reacting.
• Gay-Lussac’s law says that in this reaction we will always see 2 volumes of hydrogen reacting with 2 volumes of oxygen to produce 2 volumes of gaseous water as long as the temperature and pressure remain constant.
• For example, 2 L of hydrogen gas react with 1 L of oxygen gas to produce 2 L of gaseous water; 10 gallons of hydrogen gas react with 5 gallons of oxygen gas to produce 10 gallons of gaseous water; 200 cups of hydrogen gas react with 100 cups of oxygen gas to produce 200 cups of water, etc.
• As a side note, if you reacted 2 L of hydrogen gas with 8000 L of oxygen gas, you would still only get 2 L of gaseous water because you would run out of hydrogen gas before oxygen gas.
Based on Gay-Lussac’s law and experimental observations, Amedeo Avogadro in 1811 explained the law of combining volumes by stating that equal volumes of all gases, when measured at the same temperature and pressure, contain the same number of molecules.

Further studies by Avogadro led to the next step in understanding the relationships between masses of material and the number of molecules, covered in the next Unit.