Chemistry I
Chapter 3 – Scientific Measurement

Learning Goals:
1. **Students will understand how to use scientific measurement as a method of quantifying matter.** 2. **Students will be able to represent measurements in scientific notation, identify differences in accuracy and precision, and illustrate significance of measurements.**

Q1: *How do scientists express the degree of uncertainty in their measurements?*
Q2: *How is dimensional analysis used to solve problems?*

3.1 Using and Expressing Measurements

- A *measurement* is a quantity that has both a number and a unit (ex. Height, age, body temperature, etc)
- *Measurement* is a fundamental part of all science. In *chemistry*, we will be using extremely large and small values a lot; therefore, we will try to represent those #'s in what's called *scientific notation*
- How do we do that?

Sample Problem 3.1, p.63
Solve each problem and express the answer in scientific notation.
(a) $(8.0 \times 10^{-2}) \times (7.0 \times 10^{-5})$ (b) $(7.1 \times 10^{-2}) + (5 \times 10^{-3})$

- Ok, once we've made a measurement, how do we know if it is correct?

Accuracy vs. *Precision*

(Figure 3.2, p.64)

- What if there is an error?

  Simply calculate to see how much there was!

  <u>*Percent Error* Equation</u>

<u>Sample Problem 3.2, p.65</u>

The boiling point of pure water is measured to be 99.1^{o}C. Calculate the percent error.

- When making measurements, it is critical to try to be as accurate as possible. However, there is still always going to be some degree of *uncertainty* in the value measured.
- The *significant figures* in a measurement include all of the digits that are known, plus one last digit that is estimated.
  (Example in Figure 3.3, p.66 – thermometer reading)

Rules for Determining "Sig Figs" can be found on p. 67

<u>Sample Problem 3.3, p.68</u>
How many significant figures are in each measurement?

a. 123 m

b. 40,506 mm

c. 9.8000×10^4 m

d. 22 meter sticks

e. 0.07080 m

f. 98,000 m

- Rounding? Not too tough after some practice!

<u>Sample Problem 3.4, p.69</u>
Round off each measurement to the number of *significant figures* shown in parentheses. Write the answers in *scientific notation.*

a. 315.721 meters (four)

b. 0.001775 meter (two)

c. 8792 meters (two)

d. 7,158 grams (three)

- Ok, determining "sig figs" is pretty easy, but what happens when we have to calculate?

Rules:
Adding and Subtracting = round the answer to match the measurement with the least number of decimal places in the problem

Sample Problem 3.5, p.70
a. 12.52 m + 349.0 m + 8.24 m =

b. 74.626 m – 28.34 m =

Multiplying and Dividing = round the answer to match the measurement with the least # of sig figs

Sample Problem 3.6, p.71
a. 7.55 m x 0.34 m =

b. 2.10 m x 0.70 m =

c. 2.4526 m^2 ÷ 8.4 m =

d. 0.365 m^2 ÷ 0.0200 m =

3.2 Units of Measurement

Review … what is a *measurement*?

- We've talked plenty about the numbers … what about those units?

- In science, the *International System of Units* is used to express the unit. It is basically a revised version of the metric system.

Table 3.1		
SI Base Units		
Quantity	**SI base unit**	**Symbol**
Length	Meter	m
Mass	Kilogram	kg
Temperature	Kelvin	K
Time	Second	s
Amount of substance	Mole	mol
Luminous intensity	Candela	cd
Electric current	Ampere	A

- How can each base unit be broken down? *By powers of 10!*

Table 3.2		
Commonly Used Metric Prefixes		
Prefix	**Symbol**	**Meaning**
Kilo	k	1000
BASE UNIT	m, L, g, etc	
Deci	d	1/10
Centi	c	1/100
Milli	m	1/1000
Micro	µ	1/1000000
Nano	p	1/1000000000

- Here are a few more things from Section 3.2 …
- Space occupied by an object is its *volume*. *Volume* has a base unit called a *Liter* (L)

$$1 \text{ L} = 1000 \text{ mL} = 1000 \text{ cm}^3$$

- Temperature conversion will be covered later when we discuss Gas Laws
- *Density* is the ratio of the mass of an object to its volume.

<u>Equation + Sample Problem 3.8, p.82:</u>

3.3 Solving Conversion Problems

When measurements are made, generally there are several different ways that can be used to express a quantity. For example, 1 dollar = 4 quarters = 10 dimes = … you get the idea

Therefore, as a scientist, you need to know how to *convert* from one unit to another. This is done using *conversion factors*

- A *conversion factor* is a ratio of equivalent measurements

  Examples: $\frac{\text{10 dimes}}{\text{1 dollar}}$ or $\frac{\text{3 dollars}}{\text{12 quarters}}$

- When a measurement is multiplied by a conversion factor, the numerical value generally changes, but the actual size of the quantity measured remains the same.
- *Dimensional Analysis* is a way to analyze and solve problems using the units, or dimensions, of the measurements.

  Sample Problem 3.9, p.86

  How many seconds are in a workday that lasts exactly eight hours?

  Sample Problem 3.10, p.87

  The directions for an experiment ask each student to measure 1.84 g of copper (Cu) wire. The only copper wire available is a spool with a mass of 50.0 g. How many students can do the experiment before the copper runs out?

Sample Problem 3.11, p.88

Express 750 dg in grams

Sample Problem 3.12

What is the volume of a pure silver coin that has a mass of 14 g? The density of silver (Ag) is 10.5 g/cm^3?

Sample Problem 3.13, p.90

The diameter of a sewing needle is 0.073 cm. What is the diameter in micrometers?