Chapter 3 Outline
Scientific Measurement

Section 3.1 – Measurements and Their Uncertainty

- A _____ is a quantity that has both a _____ and a _____.
- The _____ typically used in the sciences are those of the _____ _____.
- In _____, a given number is written as the product of two numbers: a _____ and 10 raised to a _____.
- In scientific notation, the _____ is always a number equal to or greater than _____ and less than _____.
- **Sample Problems**
- Write the following numbers in scientific notation:

  39400000

  2800

  0.000567

  0.0000002

- Write the following numbers in regular notation:

  3.22×10^{4}

  2.1×10^{-5}

  8×10^{2}

  7.90×10^{-6}

- _____ is a measure of how _____ a measurement comes to the actual or _____ _____.
- _____ is a measure of how close a _____ of measurements are to _____.
- Error =
- The _____ is the correct value.
- The _____ is the value measured in the _____.
- The _____ is the absolute value of the error divided by the _____.
- Percent Error =
- So in other words,
- %E =

- **Sample Problem**
- A block of aluminum has a mass of 147.3g. A student measures the mass of the block as 138.9g. What is the student's error?

- What is the percent error?

- The _____ in a measurement include all the digits that are _____, plus a last digit that is _____.
- **Rules for Significant Figures**
- Every _____digit is significant. Ex: 254 or 65.43
- Zeros _____ significant figures are significant. Ex: 3005 or 1.083
- Zeros _____ (to the left) the significant figures are not significant. Ex: 0.07902 or 0.6932
- Zeros _____ (to the right) the significant figures AND after the decimal place are significant. Ex: 20.3200 or 63000
- Numbers that can be _____ and _____ _____ have an infinite number of significant figures. 370 crayons or 1km = 1000m
- In general, a _____ answer cannot be more precise than the _____ measurement from which it was calculated.
- <u>Addition and Subtraction</u>
- When _____, your answer can only have the same amount of _____ _____ as the number with the _____ _____ of decimal places.
- **Sample Exercise**
- Calculate the sum of the three measurements. Give the answer to the correct number of significant figures.

  12.52 m + 349.0 m + 8.24 m =
- **Practice Exercise**
- Perform each operation. Express your answers to the correct number of significant figures.

  a. 61.2 m + 9.35 m + 8.6 m =

  b. 34.61 m – 17.3 m =

- When _____, your answer can only have the same amount of _____ as the number with the _____ amount of significant figures.
- **Sample Exercise**
- Perform the following operations. Give the answers to the correct number of significant figures.

  7.55 m x 0.34 m =
- **Practice Exercise**
- Solve each problem and report your answer with the correct amount of significant figures.

  2.10 m x 0.70 m =

  8432 m / 12.5 =
- **Section 3.1 Assessment**

  1. How are accuracy and precision evaluated?

  2. A technician experimentally determined the boiling point of octane to be 124.1◦C. The actual boiling point of octane is 125.7◦C. Calculate the error and the percent error.

  3. Determine the number of significant figures in each of the following:

  a. 11 soccer players

  b. 0.070020 m

  c. 10800 m

  d. 5.00 m^3

  4. Solve each of the following and express your answer with the correct number of significant figures.

  a. 0.00072 x 1800 =

  b. 0.912 – 0.047 =

  c. 54000 x 3500000000 =
- **Section 3.2 – The International System of Units**
- The International system of Units (SI) is a revised version of the _____ that scientists use around the world.

Quantity	SI Base Unit	Symbol
	meter	m
mass		kg
temperature		K
time	second	
amount of substance		mol
luminous intensity	candela	
electric current		A

- _____ are used to show a very _____ or _____ quantity.
- For your prefixes sheet it is important to remember the following:

Example of Base Units	Example of Prefix Units
m	cm
L	mL
g	kg

- Write the conversion factors for the following:

  a. cm → m

  b. g → kg

  c. s → ns

  d. dL → L

  - Some units are a _____ of SI base units. These are called _____.
  - Volume = length x width x height
    (m) (m) (m) =
  - Density = mass (kg) =
    volume (m^3)

- _____ is the amount of _____ that an object contains. The SI unit is _____.
- _____ is the force that measures the pull of _____ on a given _____. The SI unit is _____.
- Since _____ is based on _____, it changes with _____.
- _____ stays _____ regardless of location.
- _____ is a measure of how _____ _____an object is. (It is the measure of the _____ of an object's particles)
- There are 3 temperature scales that are used: _____.
- _____ is zero on the _____ scale.
- Kelvin temperature is _____ to the kinetic energy (speed) of the particles.
- If the particles are _____, then the Kelvin temperature is _____.

- Since the particles cannot go slower than _____, then the Kelvin scale does not have any _____.
- The following formulas are used to convert between temperatures:

  $K = {}^\circ C + 273$ $\quad {}^\circ C = 5/9({}^\circ F - 32)$

  ${}^\circ C = K - 273$ $\quad {}^\circ F = 9/5({}^\circ C) + 32$

- **Sample Exercise**
- Normal human body temperature is 37◦C. What is that temperature in kelvin?

- **Practice Exercise**
- Make the following temperature conversions.
  a. 77.2K → ◦C

  b. 120◦C → ◦F

  c. 56◦F → K

- _____ is the ability to do _____ or supply _____.
- The SI unit of energy is the _____.
- In America, we use _____ instead of Joules.

- **Section 3.2 Assessment**

1. What are the SI units for the 5 common base units used in Chemistry?

2. What is the symbol and meaning for each prefix?
   a. milli-
   b. nano-
   c. deci-
   d. centi-
3. List the following units in order from largest to smallest: mL, cL, mL, L, dL.

4. What is the volume of a paperback book 21 cm tall, 12 cm wide, and 3.5 cm thick?

5. State the difference between weight and mass.

6. Convert 170◦C to kelvin.

7. State the relationship between joules and calories.

- **Section 3.3 – Conversion Problems**
- A _____ is a ratio of two equivalent measurements.
- Whenever two measurements are _____, then the ratio equals 1.
  12 in = 1 ft or 1 ft = 12 in
  Ratio form:
  $\frac{12\text{ in}}{1\text{ ft}}$ or $\frac{1\text{ ft}}{12\text{ in}}$
- _____ is a way to analyze and solve problems using the _____ of the measurements.
- Some conversion factors that you should be familiar with involve time:
  1 min =
  60 min =
  24 hr =
  356 days =
  3600s =
- **Sample Problem**
- How many seconds are in a workday that lasts exactly eight hours?

- **Practice Problems**
- How many minutes are there in exactly 1 week?
- How many seconds are in exactly 40 hours?
- How many years is 895600000 s?
- **Sample Problem**
- Convert 750 dg to grams.
- **Practice Problems**
- Convert 0.044 km to meters.
- Convert 6.7 s to milliseconds.
- Convert 4.6 mg to grams.

- **Sample Problem**
- What is 0.073 cm in micrometers?

- **Practice Problems**
- Convert 0.227 nm to centimeters.

- Convert 1.3 x 10^4 km to decimeters.

- Convert 1325 dag to megagrams.

- **Sample Problems (Honors)**
- Convert 60 g/mL to kg/dL.

- **Practice Problems (Honors)**
- Convert 90 km/hr to m/s.

- Convert 78 hg/mL to g/L.

- **Sample Problem (Honors)**
- Convert 20 km^2 to cm^2.

- **Practice Problems (Honors)**
- Convert 140 dm^3 to hm^3.

- Convert 50 m/s^2 to km/hr^2.

- Here is a list of other conversion factors that you need to memorize:
  1 in. =
  1 kg =
  1 cm^3 =
  1 cal =

- **Sample Problem**
- Convert 120 lbs. into kg.

- **Practice Problems**
- Convert 250 cal into joules.

- Convert 50 cm^3 into liters.

- Convert 25 m into feet.

- **Section 3.3 Assessment**

1. What conversion factor would you use to convert between these pairs of units?
   a. minutes to hours

   b. grams to milligrams

   c. cubic decimeters to milliliters

2. Make the following conversions:
   a. 14.8 g to micrograms

   b. 3.72×10^{-3} kg to grams

   c. 66.3 L to cubic centimeters

3. An atom of gold has a mass of 3.271×10^{-23} g. How many atoms of gold are in 5.00 g of gold?

4. Convert the following:
   a. 7.5×10^4 J to kilojoules

   b. 3.9×10^5 mg to decigrams

   c. 2.21×10^{-4} dL to microliters

5. (Honors) Light travels at a speed of 3.00×10^{10} cm/s. What is the speed of light in kilometers per hour?

- **Section 3.4 – Density**
- _____ is the ratio of the _____ of an object to its _____.
- Density =

- _____ is an _____ that depends only on the _____ of a substance, not on the size of the sample.
- The density of a substance generally _____ as its temperature _____.
- _____ is an exception to this rule.
- **Sample Problem**
- A copper penny has a mass of 3.1 g and a volume of 0.35 cm^3. What is the density of copper?

- **Practice Problems**
- A bar of silver has a mass of 68.0 g and a volume of 6.48 cm^3. What is the density of silver?

- A substance has a density of 0.38 g/mL and a volume of 20 mL. What is the mass of the object?

- A metal block has a density of 0.66 g/cm^3 and has a mass of 2 kg. What is the volume of the block?

- **Section 3.4 Assessment**

1. What determines the density of an object?

2. How does density vary with temperature?

3. A weather balloon is inflated to a volume of 2.2 x 10^3 L with 37.4 g of helium. What is the density of helium in grams per liter?

4. A 68 g bar of gold is cut into 3 equal pieces. How does the density of each piece compare to the density of the original gold bar?

5. A plastic ball with a volume of 19.7 cm^3 has a mass of 15.8 g. Would this ball sink or float in a container of gasoline? (Density of gasoline = 0.675 g/cm^3)

6. What is the volume, in cubic centimeters, of a sample of cough syrup that has a mass of 50.0 g? The density of cough syrup is 0.950 g/cm^3.

7. What is the mass, in kilograms, of 14.0 L of gasoline? (Assume that the density of gasoline is 0.680 g/cm^3.)