Chemistry 120 Spring 17

Introduction to Inorganic Chemistry

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Online Tests on Following days

March 24, 2017: Test 1 (Chapters 1-3)
April 7, 2017 : Test 2 (Chapters 4-5)
April 28, 2017: Test 3 (Chapters 6,7 &8)
May 12, 2017 : Test 4 (Chapters 9, 10 &11)
May 15, 2017: Make Up Exam: Chapters 1-11)

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Scientific Method

The scientific method has five steps

1. Observation.
2. Formulation of a question (hypothesis)
3. Pattern recognition, summarizing information (scientific laws)
4. Developing theories. (Hypothesis and eventfully theory)
5. Further Experimentation and loosing to first step to keep it improving as we discover more and more.

Scientific Method

The scientific method has five steps

1. Observation **involves qualitative or quantitative measurements**
1. Formulation of a question (hypothesis)
2. Summarizing information, Pattern recognition, (scientific laws) involves **measurements.**
3. Developing theories. (Hypothesis and eventfully theory)
4. Further Experimentation and loosing to first step to keep it improving as we discover more and more.

Two types of measurements qualitative or quantitative

Measurement Systems

Qualitative Measurement

- The determination of the dimensions, capacity, quantity, or extent of something.
- Common types measurements made in the laboratory:
  - Mass
  - Volume
  - Temperature
  - Pressure
  - concentration

Measurement Systems

Systems of Measurement

- English System (commerce):
  - inch, foot, pound, quart, and gallon
- Metric System (scientific work):
  - gram, meter, and liter
  - More convenient to use (decimal unit system).

Metric System Units

- There is one base unit for each type of measurement (length, mass, volume, etc.).
- Add prefixes to the base unit to indicate the size of the unit.
- The prefix is independent of the base unit and always remains constant.

Metric System Units

Common Metric System Prefixes

Table 2.1 Common Metric System Prefixes with Their Symbols and Mathematical Meanings

	Prefix*	Symbol	Mathematical Meaning†
Multiples	giga-	G	1,000,000,000 (10^9, billion)
	mega-	M	1,000,000 (10^6, million)
	kilo-	k	1000 (10^3, thousand)
Fractional Parts	deci-	d	0.1 (10^{-1}, one-tenth)
	centi-	c	0.01 (10^{-2}, one-hundredth)
	milli-	m	0.001 (10^{-3}, one-thousandth)
	micro-	μ (Greek mu)	0.000001 (10^{-6}, one-millionth)
	nano-	n	0.000000001 (10^{-9}, one-billionth)
	pico-	p	0.000000000001 (10^{-12}, one-trillionth)

*Other prefixes also are available but are less commonly used.

†The power-of-10 notation for denoting numbers is considered in Section 2.6.

Metric System Units

Metric Length Units

- Meter (m):
  - Base unit of length in the metric system.
- Length is measured by determining the distance between two points.

Metric System Units

Comparison of the Base Unit of Length (Meter)

LENGTH

- A meter is slightly larger than a yard.
- 1 meter = 1.09 yards.
- A baseball bat is about 1 meter long.

Metric System Units

Metric Mass Units

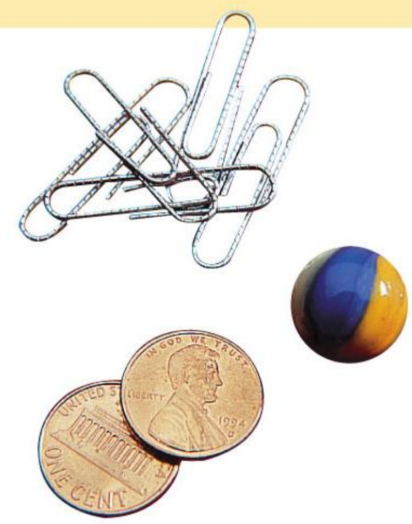
- Gram (g):
  - Base unit of mass in the metric system.
- Mass is measured by determining the amount of matter in an object.
  - Mass – measure of the total quantity of matter in an object
  - Weight – measure of the force exerted on an object by gravitational forces

Metric System Units

Comparison of the Base Unit of Mass (Gram)

MASS

- A gram is a small unit compared to a pound.
- 1 gram = 1/454 pound.
- Two pennies, five paper-clips, and a marble have masses of about 5, 2, and 5 grams, respectively.



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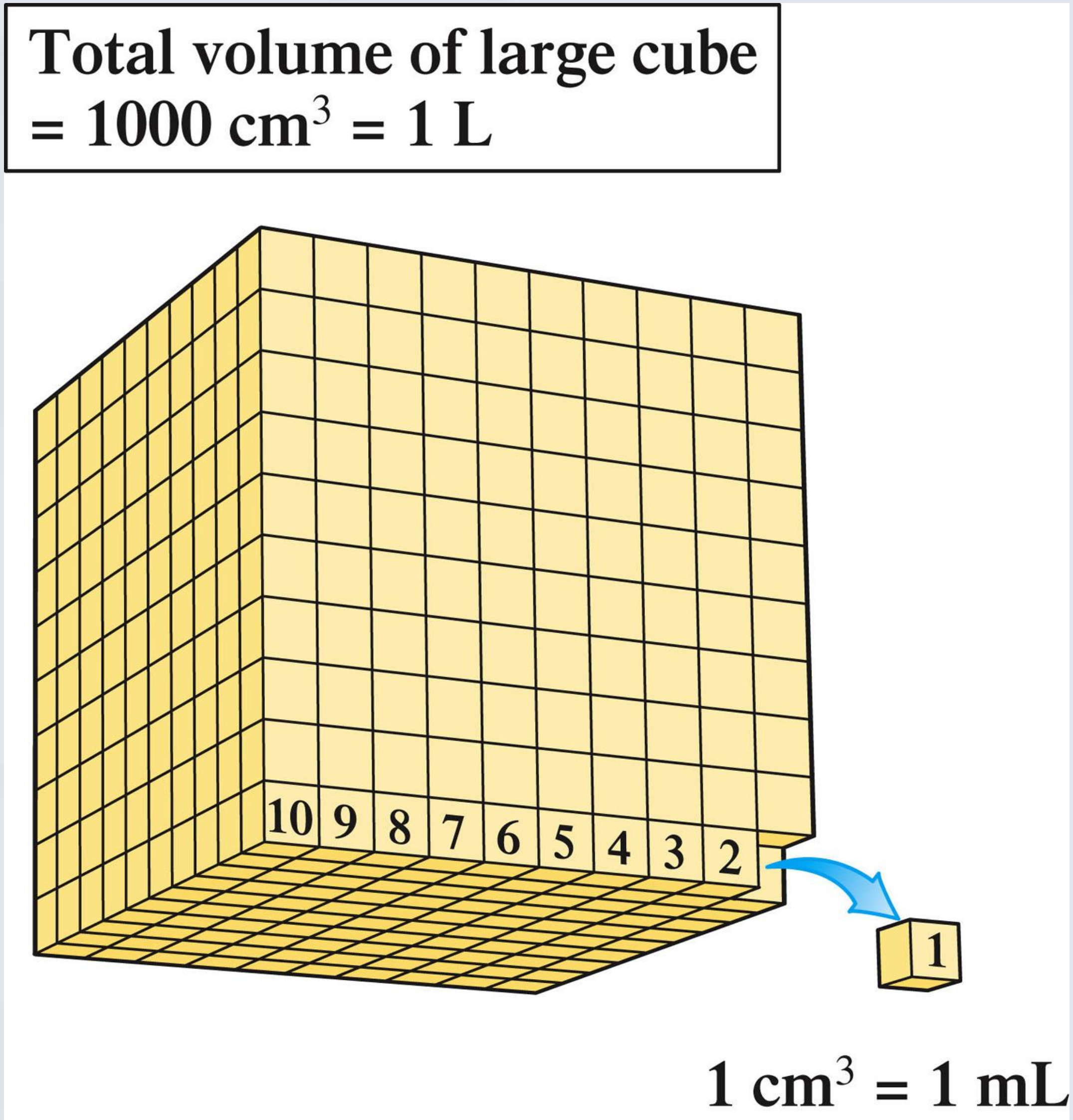
Metric System Units

Metric Volume Units

- Liver (L):
  - Base unit of volume in the metric system.
- Volume is measured by determining the amount of space occupied by a three-dimensional object.
- 1 liter = 1000 cm^3
- 1 mL = 1 cm^3
- mL generally used for liquids and gases.
- cm^3 used for solids

Metric System Units



Metric System Units

Comparison of the Base Unit of Volume (Liter)

VOLUME

- A liter is slightly larger than a quart.
- 1 liter = 1.06 quarts.
- Most beverages are now sold by the liter rather than by the quart.

Exact and Inexact Numbers

Exact Number

- A number whose value has no uncertainty associated with it – that is, it is known exactly.
  - Definitions – 12 objects in a dozen
  - Counting – 15 pretzels in a bowl
  - Simple fractions – ½ or ¾

Exact and Inexact Numbers

Inexact Number

- A number whose value has a degree of uncertainty associated with it.
- Results any time a measurement is made.

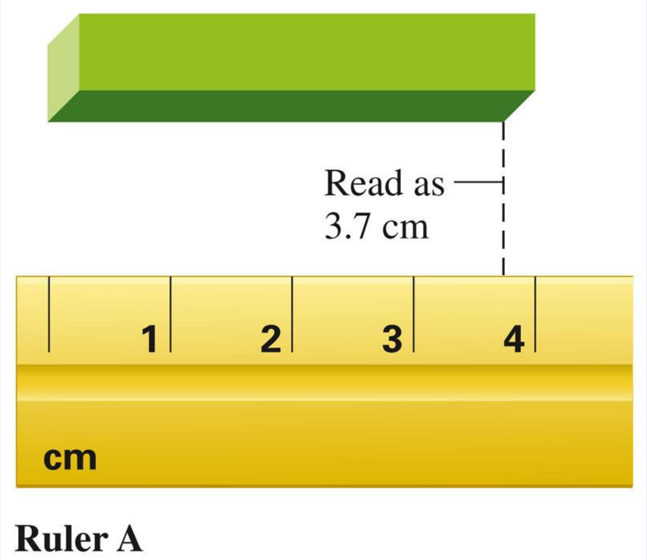
Uncertainty in Measurement and Significant Figures

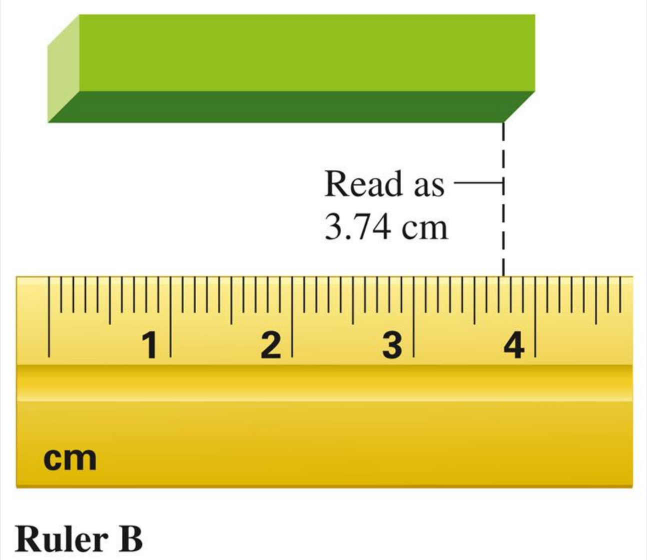
Uncertainty in Measurements

- A digit that must be estimated is called uncertain.
- A measurement always has some degree of uncertainty.
- Record the certain digits and the first uncertain digit (the estimated number).

Uncertainty in Measurement and Significant Figures

Consider These Rulers





- Measurements made with ruler A will have greater uncertainty than those made with ruler B.
- Ruler B is more precise than Ruler A.

Uncertainty in Measurement and Significant Figures

Significant Figures

- Digits in a measurement that are known with certainty plus one digit that is estimated.

  # Sig Figs = all certain digits + one estimated digit

Uncertainty in Measurement and Significant Figures

Guidelines for Determining Significant Figures

1. In any measurement, all nonzero digits are significant.
   - 3456 has 4 sig figs.

Uncertainty in Measurement and Significant Figures

Guidelines for Determining Significant Figures

- There are three classes of zeros.

a. Leading zeros are zeros that are at the beginning of a number. These do not count as significant figures.
   - 0.048 has 2 sig figs.

Uncertainty in Measurement and Significant Figures

Guidelines for Determining Significant Figures

b. Confined zeros are zeros between nonzero digits. These always count as significant figures.

- 16.07 has 4 sig figs.

Uncertainty in Measurement and Significant Figures

Guidelines for Determining Significant Figures

c. Trailing zeros are zeros at the right end of the number. They are significant only if the number contains a decimal point.

- 9.300 has 4 sig figs.

Uncertainty in Measurement and Significant Figures

Guidelines for Determining Significant Figures

d. Trailing zeros are zeros at the right end of the number. They are not significant if the number lacks an explicitly shown decimal point.

- 150 has 2 sig figs.

Significant Figures and Mathematical Operations

Rounding Off Numbers

- Process of deleting unwanted (nonsignificant) digits from calculated numbers.
  1. If the first digit to be deleted is 4 or less, simply drop it and all the following digits.
     - 5.83298 becomes 5.83 (for 3 sig figs).
  2. If the first digit to be deleted is 5 or greater, that digit and all that follow are dropped, and the last retained digit is increased by one.
     - 7.86541 becomes 7.87 (for 3 sig figs).

Significant Figures and Mathematical Operations

Operational Rules

1. In multiplication and division, the number of significant figures in the answer is the same as the number of significant figures in the measurement that contains the fewest significant figures.

$$1.342 \times \underline{5.5} = 7.381 \rightarrow \underline{7.4}$$

Significant Figures and Mathematical Operations

Operational Rules

2. In addition and subtraction, the answer has no more digits to the right of the decimal point than are found in the measurement with the fewest digits to the right of the decimal point.

$$\begin{array}{r} 23.445 \\ +\quad 7.8\underline{3} \\ \hline 31.275 \end{array} \xrightarrow{\text{Corrected}} 31.2\underline{8}$$

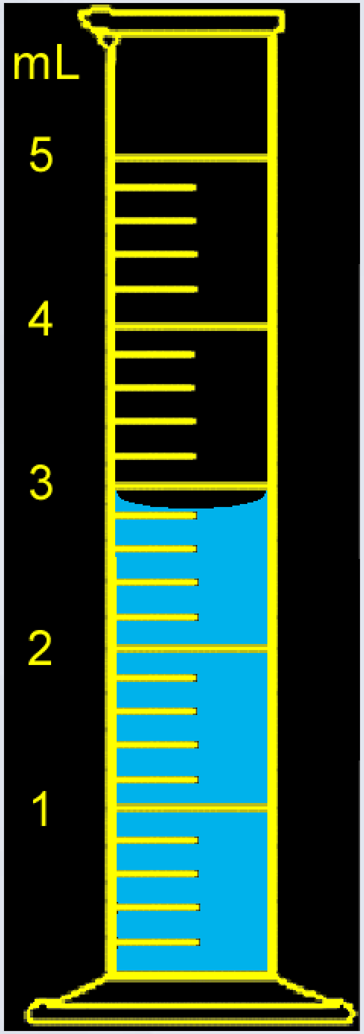
Significant Figures and Mathematical Operations

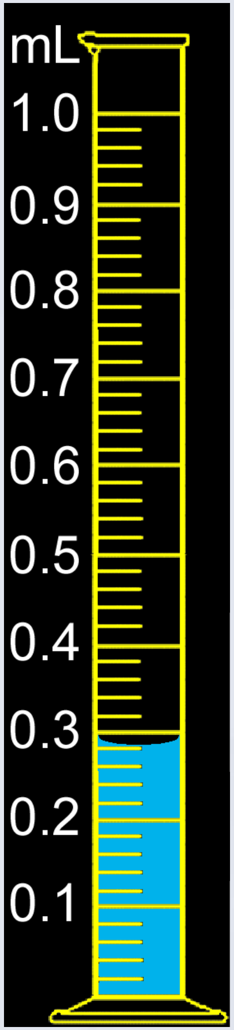
Concept Check

You have water in each graduated cylinder shown. You then add both samples to a beaker.

How would you write the number describing the total volume?

What limits the precision of this number?





$2.80 + 0.280 = 3.080$

Significant Figures and Mathematical Operations

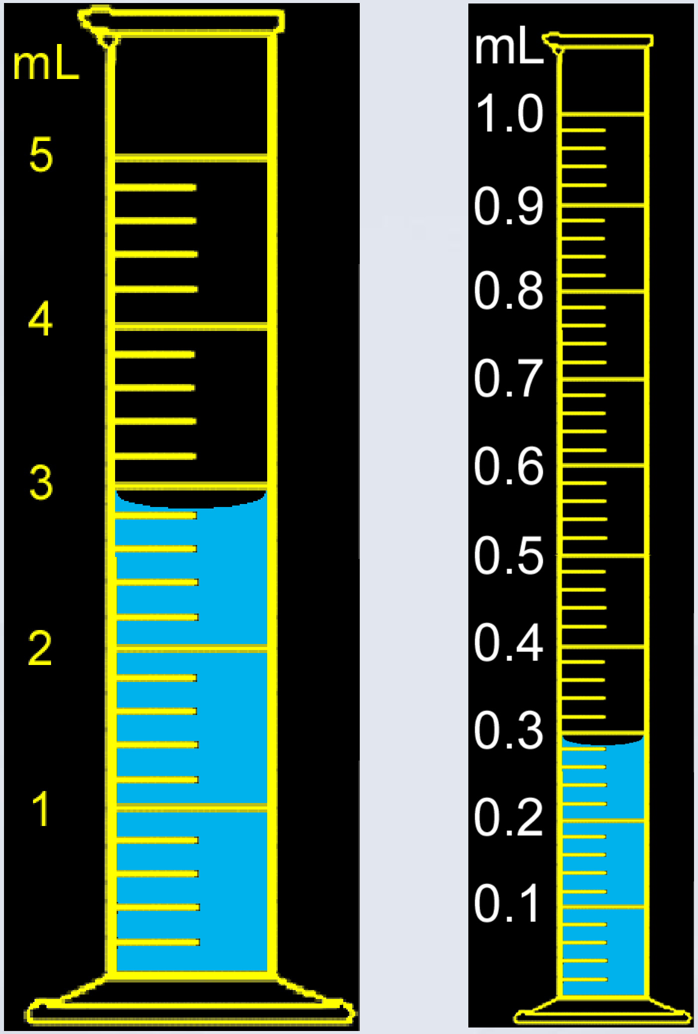
Concept Check

You have water in each graduated cylinder shown. You then add both samples to a beaker.

How would you write the number describing the total volume?

3.08 mL

What limits the precision of this number?



Significant Figures and Mathematical Operations

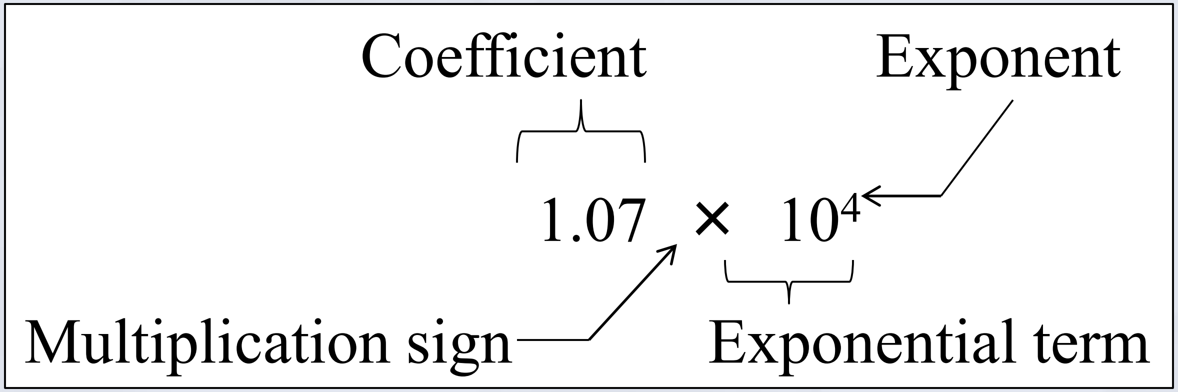
Exact Numbers

- Because exact numbers have no uncertainty associated with them, they possess an unlimited number of significant figures.
  - 1 inch = 2.54 cm, exactly.
  - 9 pencils (obtained by counting).
- Exact numbers never limit the number of significant figures in a computational answer.

Scientific Notation

Exponential Notation

- A numerical system in which numbers are expressed in the form $A \times 10^n$ where *A* is a number with a single nonzero digit to the left of the decimal place and *n* is a whole number.
  - *A* is the coefficient
  - *n* is a whole number



Scientific Notation

Converting from Decimal to Scientific Notation

1. The decimal point in the decimal number is moved to the position behind (to the right of) the first nonzero digit.
2. The exponent for the exponential term is equal to the number of places the decimal point has moved.
   - 300. written as 3.00×10^{2} (three sig figs)
   - 0.004890 written as 4.890×10^{-3} (four sig figs)

Scientific Notation

Multiplication and Division in Scientific Notation

1. To multiply exponential terms, *add* the exponents.
2. To divide exponential terms, *subtract* the exponents.

Conversion Factors

- A ratio that specifies how one unit of measurement is related to another unit of measurement.
- To convert from one unit to another, use the equivalence statement that relates the two units.

$$1 \text{ ft} = 12 \text{ in.}$$

- The two conversion factors are:

$$\frac{1 \text{ ft}}{12 \text{ in.}} \quad \text{and} \quad \frac{12 \text{ in.}}{1 \text{ ft}}$$

Conversion Factors

Equalities and Conversion Factors for Length

Table 2.2 Equalities and Conversion Factors That Relate the English and Metric Systems of Measurement

	Metric to English	English to Metric
Length		
1.00 inch = 2.54 centimeters	$\frac{1.00\text{ in.}}{2.54\text{ cm}}$	$\frac{2.54\text{ cm}}{1.00\text{ in.}}$
1.00 meter = 39.4 inches	$\frac{39.4\text{ in.}}{1.00\text{ m}}$	$\frac{1.00\text{ m}}{39.4\text{ in.}}$
1.00 kilometer = 0.621 mile	$\frac{0.621\text{ mi}}{1.00\text{ km}}$	$\frac{1.00\text{ km}}{0.621\text{ mi}}$

Conversion Factors

Equalities and Conversion Factors for Mass

Table 2.2 Equalities and Conversion Factors That Relate the English and Metric Systems of Measurement

	Metric to English	English to Metric
Mass		
1.00 pound = 454 grams	$\frac{1.00\ \text{lb}}{454\ \text{g}}$	$\frac{454\ \text{g}}{1.00\ \text{lb}}$
1.00 kilogram = 2.20 pounds	$\frac{2.20\ \text{lb}}{1.00\ \text{kg}}$	$\frac{1.00\ \text{kg}}{2.20\ \text{lb}}$
1.00 ounce = 28.3 grams	$\frac{1.00\ \text{oz}}{28.3\ \text{g}}$	$\frac{28.3\ \text{g}}{1.00\ \text{oz}}$

Equalities and Conversion Factors for Volume

Table 2.2 Equalities and Conversion Factors That Relate the English and Metric Systems of Measurement

	Metric to English	English to Metric
Volume		
1.00 quart = 0.946 liter	$\frac{1.00\ \text{qt}}{0.946\ \text{L}}$	$\frac{0.946\ \text{L}}{1.00\ \text{qt}}$
1.00 liter = 0.265 gallon	$\frac{0.265\ \text{gal}}{1.00\ \text{L}}$	$\frac{1.00\ \text{L}}{0.265\ \text{gal}}$
1.00 milliliter = 0.0338 fluid ounce	$\frac{0.0338\ \text{fl oz}}{1.00\ \text{mL}}$	$\frac{1.00\ \text{mL}}{0.0338\ \text{fl oz}}$

Dimensional Analysis

Steps for Using Dimensional Analysis

- Use when converting a given result from one system of units to another:
  1. Identify the known or given quantity (both numerical value and units) and the units of the new quantity to be determined.
  2. Multiply the given quantity by one or more conversion factors in such a manner that the unwanted (original) units are canceled, leaving only the desired units.
  3. Perform the mathematical operations indicated by the conversion factor setup.

Dimensional Analysis

Example #1

A golfer putted a golf ball 6.8 ft across a green. How many inches does this represent?

- Identify the known or given quantity (both numerical value and units) and the units of the new quantity to be determined.
  - 6.8 ft = ? in.

Dimensional Analysis

Example #1

A golfer putted a golf ball 6.8 ft across a green. How many inches does this represent?

- Multiply the given quantity by one or more conversion factors in such a manner that the unwanted (original) units are canceled, leaving only the desired units.
- The two conversion factors are:

$$\frac{1\text{ ft}}{12\text{ in}} \text{ and } \frac{12\text{ in}}{1\text{ ft}}$$

Dimensional Analysis

Example #1

A golfer putted a golf ball 6.8 ft across a green. How many inches does this represent?

- Multiply the given quantity by one or more conversion factors in such a manner that the unwanted (original) units are canceled, leaving only the desired units.

$$6.8\ \cancel{\text{ft}} \times \frac{12\ \text{in.}}{1\ \cancel{\text{ft}}} = \quad \text{in.}$$

Dimensional Analysis

Example #1

A golfer putted a golf ball 6.8 ft across a green. How many inches does this represent?

- Perform the mathematical operations indicated by the conversion factor setup.

$$6.8\ \cancel{\text{ft}} \times \frac{12\ \text{in}}{1\ \cancel{\text{ft}}} = 82\ \text{in}$$

Dimensional Analysis

Example #2

An iron sample has a mass of 4.50 lb. What is the mass of this sample in grams?

(1 kg = 2.2046 lbs; 1 kg = 1000 g)

$$4.50\ \text{lbs} \times \frac{1\ \text{kg}}{2.2046\ \text{lbs}} \times \frac{1000\ \text{g}}{1\ \text{kg}} = 2.04 \times 10^{3}\ \text{g}$$

Example # 3

Speed of light is 3.00 x 10^8 m s^{-1}. Convert the speed of light to miles per year.

Conversion factors;

6.21 x 10^{-4} mile = 1 m; mile 1 = 1.61 km; 1 km = 10^3 m;

60 s = 1 min; 60 min= 1 hr; 24 hr =1 day; 365 day= 1yr

60 s	60 min	24 hr	365 days		31536000 s
1 min	1 hr	1 day	1 yr	=	1 yr

3.00 x 10^8 m	6.21 x 10^{-4} mile	31536000 s		
1 s	1 m	1 yr	=	5.87 x 10^{12} mile/yr

Dimensional Analysis

Concept Check

What data would you need to estimate the money you would spend on gasoline to drive your car from New York to Chicago? Provide estimates of values and a sample calculation.

Density

- Ratio of the mass of an object to the volume occupied by that object.
- Common units are g/cm^3 (for solids) or g/mL (for liquids).

$$\text{Density} = \frac{\text{mass}}{\text{volume}}$$

Density

Example #1

A certain mineral has a mass of 17.8 g and a volume of 2.35 cm^3. What is the density of this mineral?

$$\text{Density} = \frac{\text{mass}}{\text{volume}}$$

$$\text{Density} = \frac{17.8\ \text{g}}{2.35\ \text{cm}^3}$$

$$\text{Density} = \boxed{7.57\ \text{g/cm}^3}$$

Density

Example #2

What is the mass of a 49.6 mL sample of a liquid, which has a density of 0.85 g/mL?

$$\text{Density} = \frac{\text{mass}}{\text{volume}}$$

$$0.85\ \text{g/mL} = \frac{x}{49.6\ \text{mL}}$$

$$\text{mass} = x = \boxed{42\ \text{g}}$$

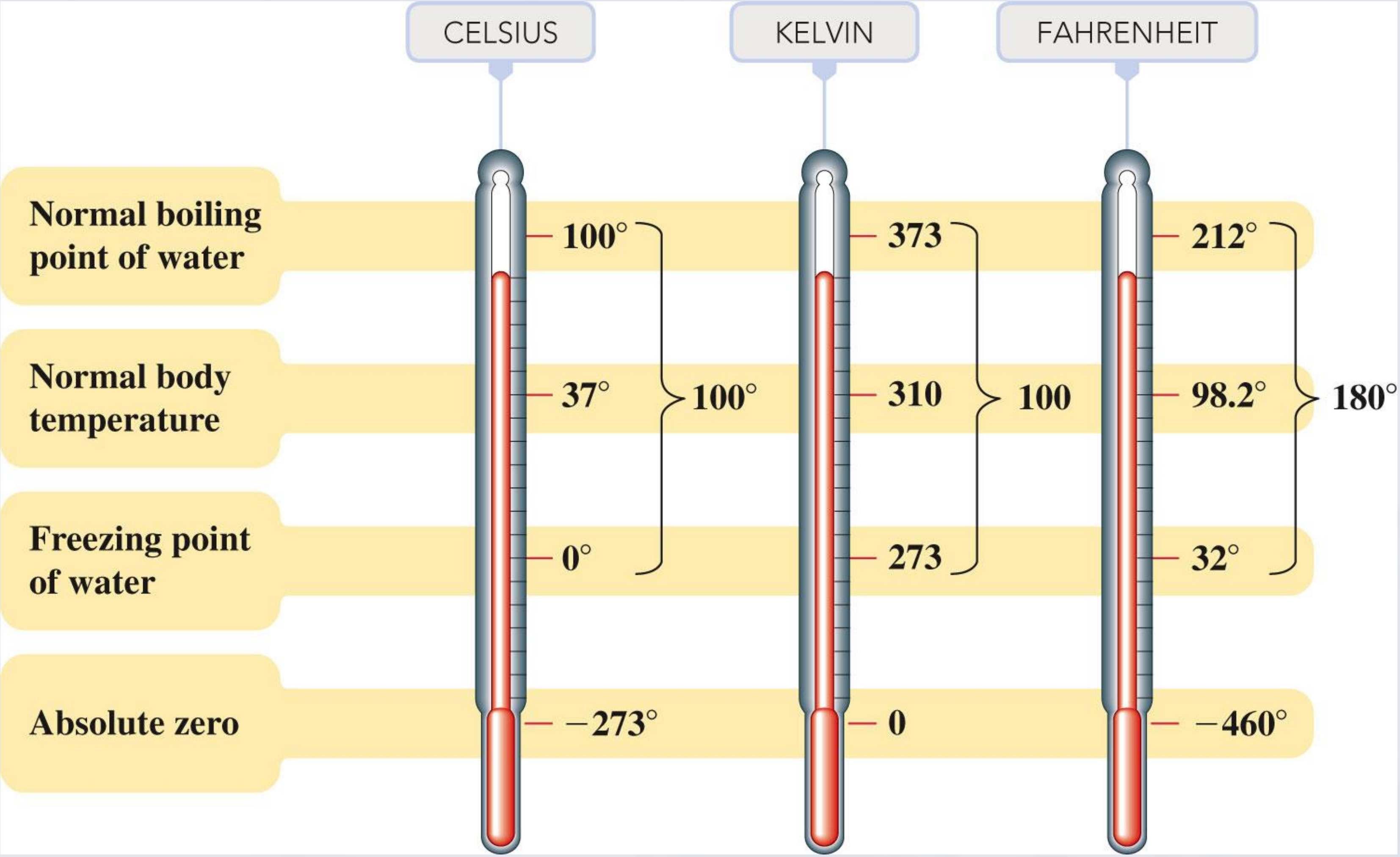
Temperature Scales

Three Systems for Measuring Temperature

- Celsius
- Kelvin
- Fahrenheit

Temperature Scales

The Three Major Temperature Scales



Temperature Scales

Converting Between Scales

$$K = °C + 273$$

$$°C = K - 273$$

$$°C = \frac{5}{9}(°F - 32)$$

$$°F = \frac{9}{5}(°C) + 32$$

Temperature Scales

Exercise

At what temperature does °C = °F?

Temperature Scales

Solution

- Since ° C equals ° F, they both should be the same value (designated as variable *x*).
- Use one of the conversion equations such as:

$$°C = \frac{5}{9}(°F - 32)$$

- Substitute in the value of *x* for both ° C and ° F. Solve for *x*.

Temperature Scales

Solution

$$°C = \frac{5}{9}(°F - 32)$$

$$x = \frac{5}{9}(x - 32)$$

$$x = -40$$

Temperature Scales

Temperature Reading and Significant figures

- Standard operating procedure: Read a thermometer to estimate the temperature to the closest degree (uncertainty is in ones place).
  - Example: 10.^{o}C or 10.^{o}F has 2 sig figs and 100.^{o}C or 100.^{o}F has 3 sig figs

Temperature Scales

Exercise

Human body temperature is 98.6 ° F. Convert this temperature to ° C and K scale.

$^oF \rightarrow {}^oC$; **$^oC = 5/9\ (^oF - 32)$**$= 5/9\ (98.6 - 32) = 5/9\ (66.6) = 37.0$

$^oC \rightarrow K$; $K = {}^oC + 273.15 = \mathbf{37.0}\ {}^oC + 273.15 = 310.2\ K$