

# Chapter 1

## Essential Ideas



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# HW Site: Sapling Learning

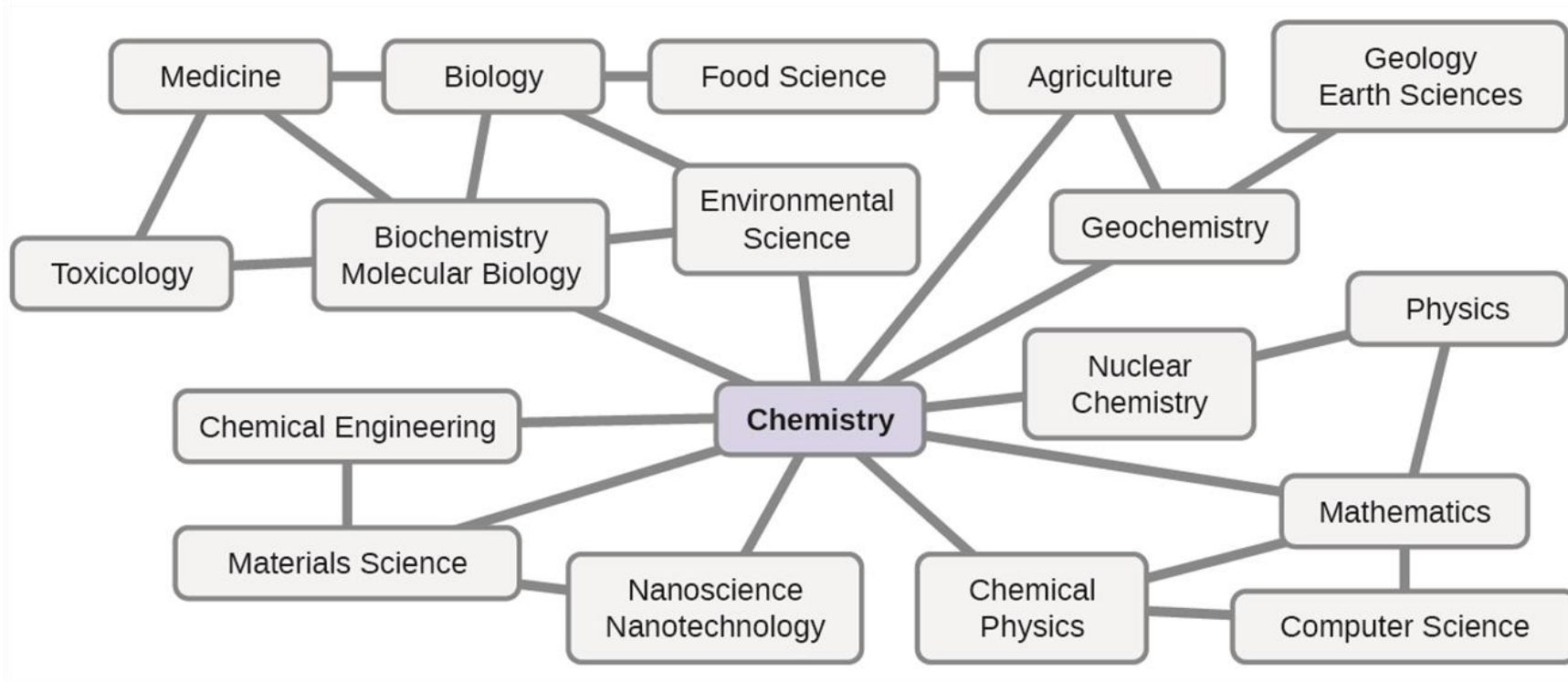
- Login your Blackboard account at [Buffalstate.edu](http://Buffalstate.edu)
- Click CHE111 >> Click Content >> Sapling HW
- Click on the US Higher Ed option at the top right.
- Create your account.
- Choose, Buffalo State College - CHE 111 - Fall19  
– KIM
- Direct pay at website or you can buy access code at Campus bookstore

# HW0A and HW0B: Extra Credit

- Login your Blackboard account at Buffalstate.edu
- Click CHE111 >> Click Content >> Sapling Learning HW
- Introduction and Review
  1. Watch Video: Introduction to Sapling Learning
  2. HW0A: How to use Sapling learning (10 pts, extra pts)
  3. HW0B: Math Review (5 pts, extra pts)
- Due: 11:50 pm, Friday September 6, 2019
- Window will be closed after due
- For questions, email me

# Chemistry: Central Science

- Chemistry is everywhere



# Gathering Empirical Knowledge — Observation

- Some observations are descriptions of the characteristics or behavior of nature — **qualitative (sometimes subjective)**
  - ✓ “The soda pop is sweet.”
  - ✓ He is tall.
- Some observations compare a characteristic to a standard numerical scale — **quantitative (very objective)**
  - ✓ “A 240 mL serving of soda pop contains 27 g of sugar.”
  - ✓ His height is 6’2”.

# Classifying Matter by Physical State

- Substances
- Phases:

<b><i>State</i></b>	<b><i>Shape</i></b>	<b><i>Volume</i></b>	<b><i>Compressible?</i></b>	<b><i>Flow?</i></b>
<b>Solid</b>	Rigid	Maintains	No	No
<b>Liquid</b>	Assumes Container's	Maintains	No	Yes
<b>Gas</b>	Assumes Container's	Assumes Container's	Yes	Yes

# Atoms and Molecules

- Atoms (C, O, N, etc)
  - are submicroscopic particles
  - are the fundamental building blocks of ordinary matter
- Molecules (CO, CO<sub>2</sub>, O<sub>2</sub>, etc)
  - are two or more atoms attached together in a specific geometrical arrangement
    - attachments are called **bonds**
    - attachments come in different strengths
  - come in different shapes and patterns
- **Chemistry** is the science that seeks to understand the behavior of matter by studying the behavior of atoms and molecules

# Periodic Table

Periodic Table of the Elements

Period	Group 1	Group 2											Group 13	Group 14	Group 15	Group 16	Group 17	Group 18
1	1 <b>H</b> 1.008 hydrogen																	2 <b>He</b> 4.003 helium
2	3 <b>Li</b> 6.94 lithium	4 <b>Be</b> 9.012 beryllium											5 <b>B</b> 10.81 boron	6 <b>C</b> 12.01 carbon	7 <b>N</b> 14.01 nitrogen	8 <b>O</b> 16.00 oxygen	9 <b>F</b> 19.00 fluorine	10 <b>Ne</b> 20.18 neon
3	11 <b>Na</b> 22.99 sodium	12 <b>Mg</b> 24.31 magnesium											13 <b>Al</b> 26.98 aluminum	14 <b>Si</b> 28.09 silicon	15 <b>P</b> 30.97 phosphorus	16 <b>S</b> 32.06 sulfur	17 <b>Cl</b> 35.45 chlorine	18 <b>Ar</b> 39.95 argon
4	19 <b>K</b> 39.10 potassium	20 <b>Ca</b> 40.08 calcium	21 <b>Sc</b> 44.96 scandium	22 <b>Ti</b> 47.87 titanium	23 <b>V</b> 50.94 vanadium	24 <b>Cr</b> 52.00 chromium	25 <b>Mn</b> 54.94 manganese	26 <b>Fe</b> 55.85 iron	27 <b>Co</b> 58.93 cobalt	28 <b>Ni</b> 58.69 nickel	29 <b>Cu</b> 63.55 copper	30 <b>Zn</b> 65.38 zinc	31 <b>Ga</b> 69.72 gallium	32 <b>Ge</b> 72.63 germanium	33 <b>As</b> 74.92 arsenic	34 <b>Se</b> 78.97 selenium	35 <b>Br</b> 79.90 bromine	36 <b>Kr</b> 83.80 krypton
5	37 <b>Rb</b> 85.47 rubidium	38 <b>Sr</b> 87.62 strontium	39 <b>Y</b> 88.91 yttrium	40 <b>Zr</b> 91.22 zirconium	41 <b>Nb</b> 92.91 niobium	42 <b>Mo</b> 95.95 molybdenum	43 <b>Tc</b> [97] technetium	44 <b>Ru</b> 101.1 ruthenium	45 <b>Rh</b> 102.9 rhodium	46 <b>Pd</b> 106.4 palladium	47 <b>Ag</b> 107.9 silver	48 <b>Cd</b> 112.4 cadmium	49 <b>In</b> 114.8 indium	50 <b>Sn</b> 118.7 tin	51 <b>Sb</b> 121.8 antimony	52 <b>Te</b> 127.6 tellurium	53 <b>I</b> 126.9 iodine	54 <b>Xe</b> 131.3 xenon
6	55 <b>Cs</b> 132.9 cesium	56 <b>Ba</b> 137.3 barium	57-71 <b>La-Lu</b> * lanthanum series	72 <b>Hf</b> 178.5 hafnium	73 <b>Ta</b> 180.9 tantalum	74 <b>W</b> 183.8 tungsten	75 <b>Re</b> 186.2 rhenium	76 <b>Os</b> 190.2 osmium	77 <b>Ir</b> 192.2 iridium	78 <b>Pt</b> 195.1 platinum	79 <b>Au</b> 197.0 gold	80 <b>Hg</b> 200.6 mercury	81 <b>Tl</b> 204.4 thallium	82 <b>Pb</b> 207.2 lead	83 <b>Bi</b> 209.0 bismuth	84 <b>Po</b> [209] polonium	85 <b>At</b> [210] astatine	86 <b>Rn</b> [222] radon
7	87 <b>Fr</b> [223] francium	88 <b>Ra</b> [226] radium	89-103 <b>Ac-Lr</b> ** actinide series	104 <b>Rf</b> [267] rutherfordium	105 <b>Db</b> [270] dubnium	106 <b>Sg</b> [271] seaborgium	107 <b>Bh</b> [270] bohrium	108 <b>Hs</b> [277] hassium	109 <b>Mt</b> [276] meitnerium	110 <b>Ds</b> [281] darmstadtium	111 <b>Rg</b> [282] roentgenium	112 <b>Cn</b> [285] copernicium	113 <b>Uut</b> [285] ununtrium	114 <b>Fl</b> [289] flerovium	115 <b>Uup</b> [288] ununpentium	116 <b>Lv</b> [293] livermorium	117 <b>Uus</b> [294] ununseptium	118 <b>Uuo</b> [294] ununoctium
			57 <b>La</b> 138.9 lanthanum	58 <b>Ce</b> 140.1 cerium	59 <b>Pr</b> 140.9 praseodymium	60 <b>Nd</b> 144.2 neodymium	61 <b>Pm</b> [145] promethium	62 <b>Sm</b> 150.4 samarium	63 <b>Eu</b> 152.0 europium	64 <b>Gd</b> 157.3 gadolinium	65 <b>Tb</b> 158.9 terbium	66 <b>Dy</b> 162.5 dysprosium	67 <b>Ho</b> 164.9 holmium	68 <b>Er</b> 167.3 erbium	69 <b>Tm</b> 168.9 thulium	70 <b>Yb</b> 173.1 ytterbium	71 <b>Lu</b> 175.0 lutetium	
			89 <b>Ac</b> [227] actinium	90 <b>Th</b> 232.0 thorium	91 <b>Pa</b> 231.0 protactinium	92 <b>U</b> 238.0 uranium	93 <b>Np</b> [237] neptunium	94 <b>Pu</b> [244] plutonium	95 <b>Am</b> [243] americium	96 <b>Cm</b> [247] curium	97 <b>Bk</b> [247] berkelium	98 <b>Cf</b> [251] californium	99 <b>Es</b> [252] einsteinium	100 <b>Fm</b> [257] fermium	101 <b>Md</b> [258] mendelevium	102 <b>No</b> [259] nobelium	103 <b>Lr</b> [262] lawrencium	

Atomic number	→ 1
	<b>H</b>
	← Symbol
	1.008
	← Atomic mass
Name	→ hydrogen

Color Code	
<span style="background-color: #ffffcc; border: 1px solid black; display: inline-block; width: 15px; height: 15px;"></span> Metal	<b>Solid</b>
<span style="background-color: #d3d3d3; border: 1px solid black; display: inline-block; width: 15px; height: 15px;"></span> Metalloid	<b>Liquid</b>
<span style="background-color: #e0e0e0; border: 1px solid black; display: inline-block; width: 15px; height: 15px;"></span> Nonmetal	<b>Gas</b>



# Classifications of Substances by Compositions

- Substances:
  - Pure substances
    1. Elements:
    2. Compounds:
  - Mixtures
    1. Homogeneous:
    2. Heterogeneous:

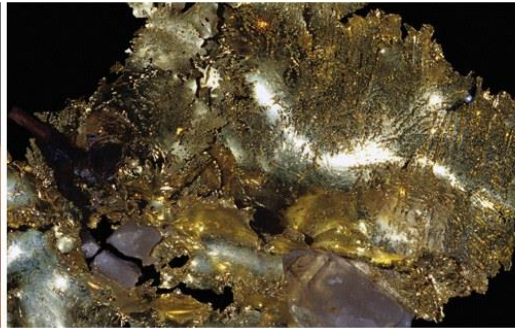
# Pure substances: Elements and Compounds

- Elements:



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diamond = carbon (C)



Gold (Au)



Sulfur (S)

- Compounds: Substances composed of two or more types of atoms
- e.g.:

# Example 1: Elements and Compounds ?

1. Silver:

2. Ice:

3. Carbon monoxide:

4. Argon:

5. Propane:

6. Sulfuric acid:

# Elements, Compounds Atoms, and Molecules

1. Silver: element consisting of silver (Ag) atoms
2. Ice: compound ( $\text{H}_2\text{O}$  molecule consisting of two H atoms and one O atom)
3. Carbon monoxide: compound (CO molecule consisting of one C atom and one O atom)

# Water, Ice and Vapor

1. All are same compounds, but different phase (solid, liquid, and gas)

# Mixtures

## Mixture

- Made up of two or more substances
- e.g.: air (nitrogen, oxygen, etc)
- Two broad categories of mixtures:
  - Heterogeneous
  - Homogeneous

# Example 2: Pure Substance or Mixture?

1. Coke:

2. Glass:

3. Sea water:

4. Coffee:

5. Caffeine:

6. Snow:

7. Gas (gasoline):

# Homogeneous Mixtures

- Same properties throughout sample
- Uniform compositions
- **Solution**
  - Thoroughly stirred homogeneous mixture

## **Ex.**

### – **Liquid solution**

- Sugar in water

### – **Gas solution**

- Air: Contains nitrogen, oxygen, carbon dioxide & other gases

### – **Solid solution**

- US 5¢ coin – Metal Alloy
  - Contains copper & nickel metals



# Heterogeneous Mixtures

- 2 or more regions of different properties
- Solution with multiple phases
- Separate layers

**Ex.**

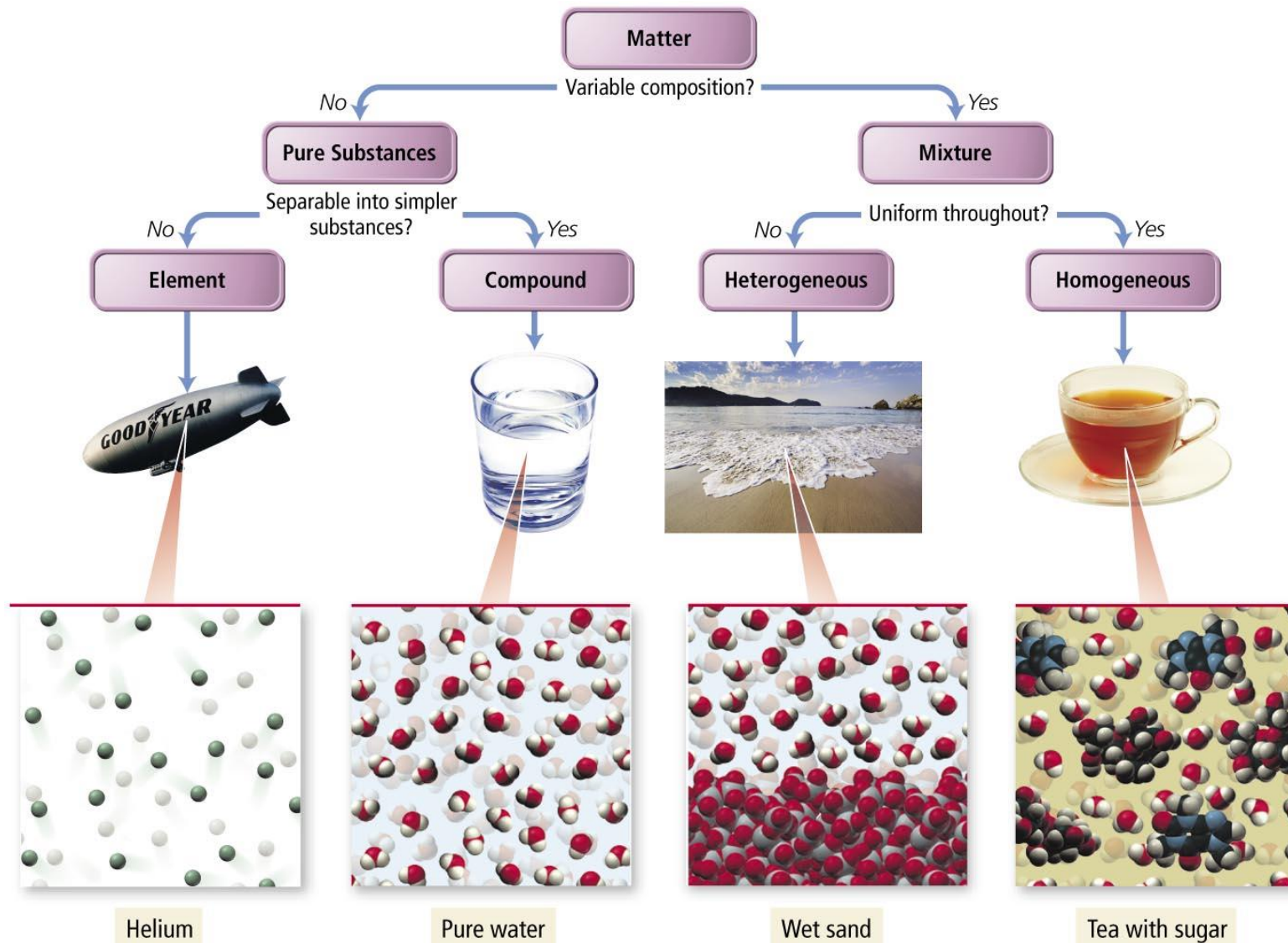
- Chocolate bar
- Rock



# Example 3: Homogeneous or Heterogeneous

1. Coke:
2. Pizza with pepperoni topping:
3. Sea water:
4. Air:
5. Our body:
6. Our planet:

# Classification of Matters by Compositions



# Physical & Chemical Properties

- Physical Properties: property that is measurable whose value describes a state of a physical system.
  1. Mass, volume, length, color, boiling point
  2. Area, solubility, concentration, etc
- Chemical Properties: any of a material's properties that becomes evident during a chemical reaction.
  1. Flammability
  2. Toxicity
  3. Chemical stability

# Physical & Chemical Changes

- Physical Change:
  1. No new substances formed
  2. Substance may change state or the proportions
  3. Ice melting, salt dissolution in water, etc
- Chemical Change
  1. Formation of new substances or compounds
  2. Involves changing chemical makeup of substances
  3. New substance has different physical properties
  4. Combustion of oil, rust formation, digestion of foods in stomach, etc

# Example 4: Physical & Chemical Changes

- Water boiling:
- Propane combustion:
- Making cocktail:
- Extraction of gold from ore:
- UV damage of your skin:
- Erosion of rock:
- Corrosion of your car:

# The Standard Units

- Scientists have agreed on a set of international standard units for comparing all our measurements called the **SI units**
  - *Système International* = International System

Quantity	Unit	Symbol
length	meter	m
mass	kilogram	kg
time	second	s
temperature	kelvin	K

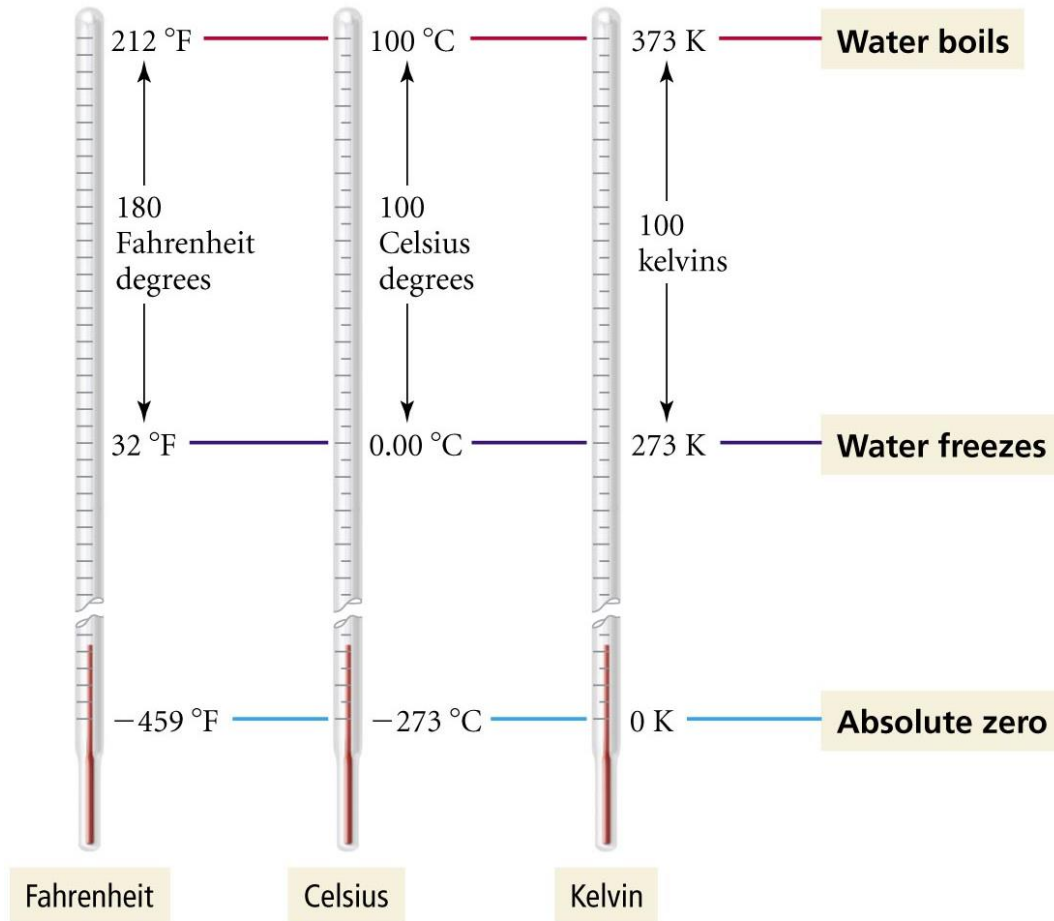
# Length, mass, and time

- Commonly use centimeters (cm)
  - 1 m = 100 cm
  - 1 cm = 0.01 m = 10 mm
  - 1 inch = 2.54 cm (exactly)
- Commonly measure mass in grams (g) or milligrams (mg)
  - 1 kg = 2.2046 pounds, 1 lb. = 453.59 g
  - 1 kg = 1000 g =  $10^3$  g
  - 1 g = 1000 mg =  $10^3$  mg
  - 1 g = 0.001 kg =  $10^{-3}$  kg
  - 1 mg = 0.001 g =  $10^{-3}$  g
- Commonly use second (s)



# Temperature Scales

- Fahrenheit scale, °F
  - used in the U.S.
- Celsius scale, °C
  - used in all other countries
- Kelvin scale, K
  - absolute scale
    - no negative numbers
  - directly proportional to average amount of kinetic energy
  - 0 K = absolute zero



# Conversion of Temperature Scales

$$^{\circ}\text{C} = \frac{(^{\circ}\text{F} - 32)}{1.8}$$

$$\text{K} = ^{\circ}\text{C} + 273.15$$

# Temperature Conversion

- 0 F  $\ggg$  K
- 300 K  $\ggg$  F

# Common Prefix Multipliers in the SI System

Prefix	Symbol	Decimal Equivalent	Power of 10
mega-	M	1,000,000	Base x $10^6$
kilo-	k	1,000	Base x $10^3$
deci-	d	0.1	Base x $10^{-1}$
centi-	c	0.01	Base x $10^{-2}$
milli-	m	0.001	Base x $10^{-3}$
micro-	$\mu$ or mc	0.000 001	Base x $10^{-6}$
nano-	n	0.000 000 001	Base x $10^{-9}$
pico	p	0.000 000 000 001	Base x $10^{-12}$

# Common Units and Their Equivalents

## Length

1 kilometer (km) = 0.6214 mile (mi)

1 meter (m) = 39.37 inches (in.)

1 meter (m) = 1.094 yards (yd)

1 foot (ft) = 30.48 centimeters (cm)

1 inch (in.) = 2.54 centimeters (cm)  
exactly

# Common Units and Their Equivalents-Continued

## Mass

1 kilogram (kg) = 2.205 pounds (lb)

1 pound (lb) = 453.59 grams (g)

1 ounce (oz) = 28.35 grams (g)

## Volume

1 liter (L) = 1000 milliliters (mL)

1 liter (L) = 1000 cubic centimeters (cm<sup>3</sup>)

1 liter (L) = 1.057 quarts (qt)

1 U.S. gallon (gal) = 3.785 liters (L)

# Intensive vs. Extensive Properties

## Intensive properties

- Independent of sample size
- Used to identify substances

**Ex.** Color

Density

Boiling point

Melting point

Chemical reactivity

## Extensive properties

- Depend on sample size

**Ex.** volume & mass

# Density

- **Density** is the ratio of mass to volume
  - is an **intensive property**
- units =  $\text{g/cm}^3$   
or  $\text{g/mL}$
- $$\text{Density} = \frac{\text{Mass}}{\text{Volume}}$$
- Volume of a solid can be determined by water displacement – Archimedes principle
- Density : solids > liquids >>> gases
- Volumes changes as Temperature changes
- Temperature should be specified.



Decide if a ring with a mass of 3.15 g that displaces 0.233 cm<sup>3</sup> of water is platinum

# Significant Figures

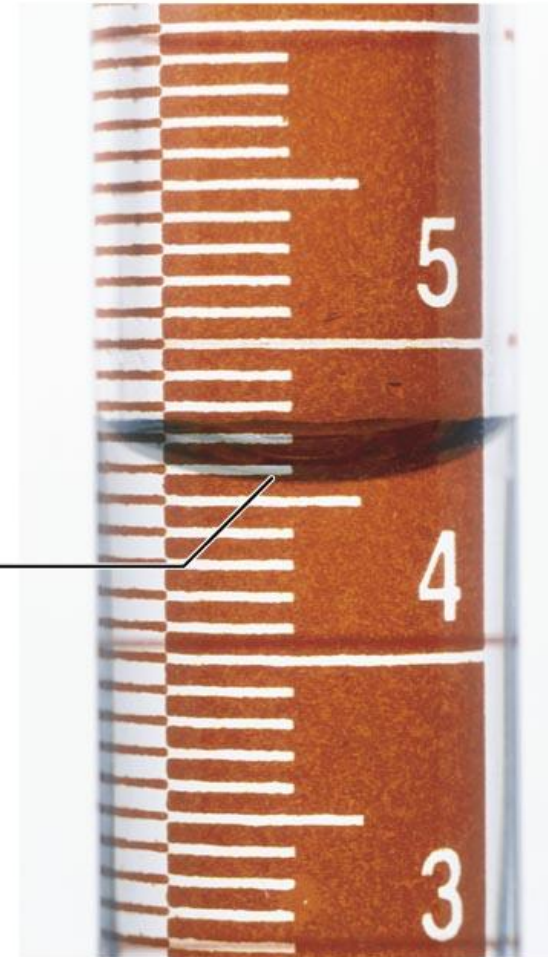
What's your measurement?

4.55 or 4.56 or 4.57?

surely

4.5X neither 4.6X nor  
4.4X

Meniscus



# Number of Significant Figures

Your measurement will be either 4.55 or 4.56 or 4.57 or etc

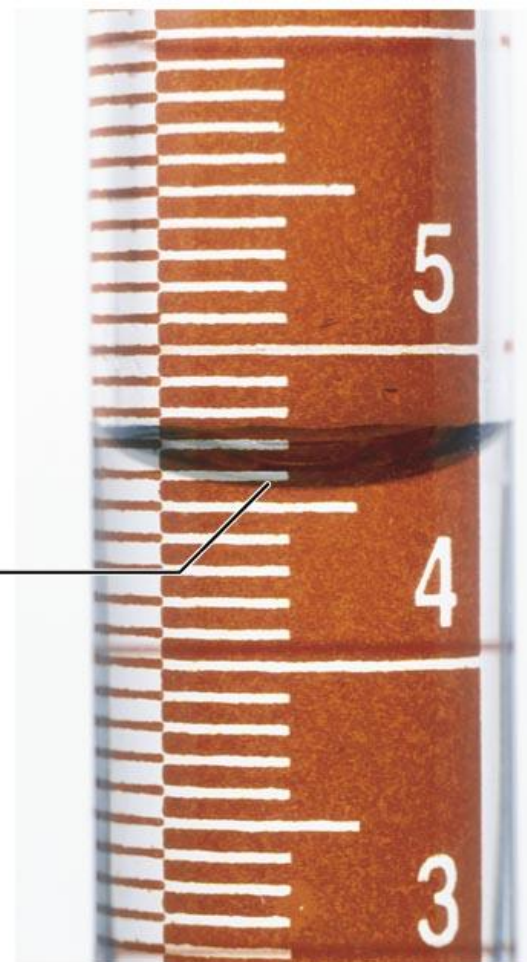
# of significance figures: 3

Uncertainty (estimates)

location: 4.57



Meniscus



What's Difference between 12.3  
and 12.30?

# Significant Figures

How many apples?

2.1 or 1.9 or 2.0 or what?

No ambiguity

Infinite number of significant numbers

(2, 2.0, 2.00, 2.000, etc, all ok, but conventionally 2)



# Counting Significant Figures

1. All non-zero digits are significant
  - 1.5 has 2 sig. figs.
2. Interior zeros are significant
  - 1.05 has 3 sig. figs.
3. Leading zeros are **NOT** significant
  - 0.001050 has 4 sig. figs.
    - $1.050 \times 10^{-3}$

# Counting Significant Figures

4. Trailing zeros may or may not be significant
- Trailing zeros after a decimal point are significant
    - 1.050 has 4 sig. figs.
  - Trailing zeros before a decimal point are significant if the decimal point is written
    - 150.0 has 4 sig. figs.
  - Zeros at the end of a number without a written decimal point are ambiguous and should be avoided by using scientific notation
    - 150 is ambiguous
    - if 150 has 2 sig. figs. then  $1.5 \times 10^2$
    - but if 150 has 3 sig. figs. then  $1.50 \times 10^2$

# Determine the number of significant figures

- 120.                      3 sig. figs.
- 120                      ambiguous
- 120.0                    4 sig. figs.
- 10000                    ambiguous
- 1 in = 2.54 cm           unlimited (not ambiguous b/c determined quantity by definition)
- 1.1 in                    2 sig. figs.



# Determine the number of significant figures

- 100 dollars                      unlimited
- 6 cars                              unlimited

# Rounding 1

- Rounding to 2 significant figures
- 2.34 rounds to 2.3
  - because the 3 is where the last sig. fig. will be and the number after it is 4 or less
- 2.37 rounds to 2.4
  - because the 3 is where the last sig. fig. will be and the number after it is 5 or greater
- 2.349865 rounds to 2.3
  - because the 3 is where the last sig. fig. will be and the number after it is 4 or less

# Rounding 2

- Rounding to 2 significant figures
- 0.0234 rounds to 0.023 or  $2.3 \times 10^{-2}$ 
  - because the 3 is where the last sig. fig. will be and the number after it is 4 or less
- 0.0237 rounds to 0.024 or  $2.4 \times 10^{-2}$ 
  - because the 3 is where the last sig. fig. will be and the number after it is 5 or greater
- 0.02349865 rounds to 0.023 or  $2.3 \times 10^{-2}$ 
  - because the 3 is where the last sig. fig. will be and the number after it is 4 or less

# Multiplication and Division with Significant Figures

- When multiplying or dividing measurements with significant figures, the result has the same number of significant figures as the measurement with the lowest number of significant figures

$$\begin{array}{ccccccc} 5.02 & \times & 89.665 & \times & 0.10 & = & 45.0118 & = & 45 \\ 3 \text{ sig. figs.} & & 5 \text{ sig. figs.} & & 2 \text{ sig. figs.} & & & & 2 \text{ sig. figs.} \\ \\ 5.892 & \div & 6.10 & = & 0.96590 & = & 0.966 \\ 4 \text{ sig. figs.} & & 3 \text{ sig. figs.} & & & & 3 \text{ sig. figs.} \end{array}$$

# Addition and Subtraction with Significant Figures

- When adding or subtracting measurements with significant figures, the result has the same number of decimal places as the measurement with the lowest number of decimal places

$$\begin{array}{r} 2.345 \\ + 0.07 \\ \hline 2.9975 \\ \hline 5.4125 \end{array} = 5.41$$

$$\begin{array}{r} 5.9 \\ - 2.221 \\ \hline 5.679 \end{array} = 5.7$$

# Both Multiplication/Division and Addition/Subtraction with Significant Figures

- When doing different kinds of operations with measurements with significant figures, do whatever is in parentheses first, evaluate the significant figures in the intermediate answer, then do the remaining steps

$$\begin{array}{rccccccc} 3.489 & \times & (5.67 & - & 2.3) & = & \\ & & 2 \text{ dp} & & 1 \text{ dp} & & \\ 3.489 & \times & 3.\underline{3}7 & = & 12 & & \\ 4 \text{ sf} & & 1 \text{ dp} \ \& \ 2 \text{ sf} & & 2 \text{ sf} & \end{array}$$

# Perform the Following Calculations to the Correct Number of Significant Figures

a)  $1.10 \times 0.5120 \times 4.0015 \div 3.4555$

0.355

b)  $+105.1$

$-100.5820$

c)  $4.562 \times 3.99870 \div (452.6755 - 452.33)$

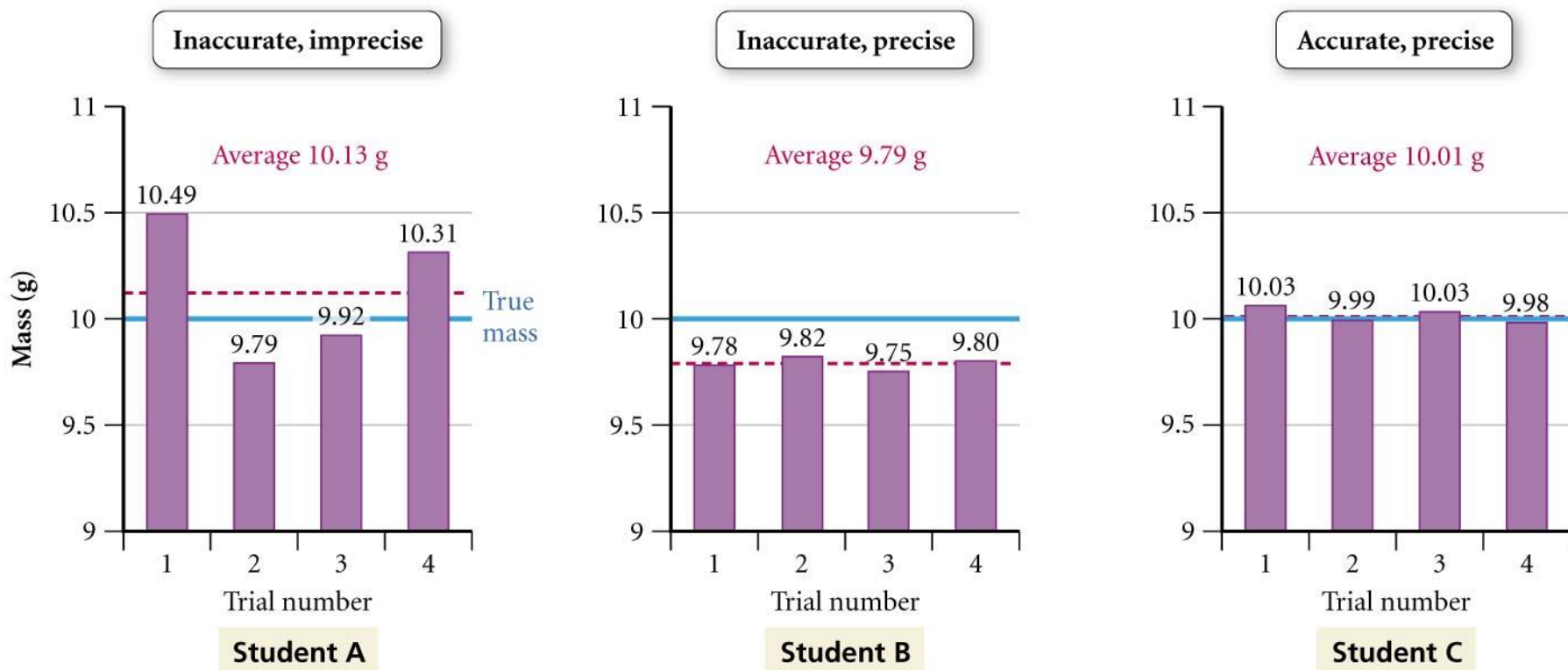
d)  $(14.84 \times 0.55) - 8.02$

# Accuracy vs. Precision

- Uncertainty comes from limitations of the instruments used for comparison, the experimental design, the experimenter, and nature's random behavior
- **Accuracy** is an indication of how close a measurement comes to the **actual** value of the quantity
- **Precision** is an indication of how close repeated measurements are to each other (consistency)
  - how reproducible a measurement is



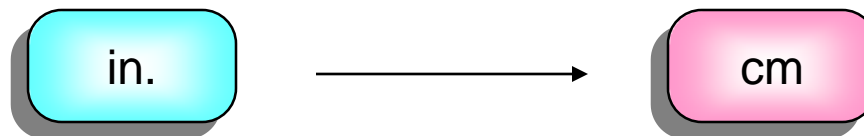
# Accuracy vs. Precision



Looking at the graph of the results shows that Student A is neither accurate nor precise, Student B is inaccurate, but is precise, and Student C is both accurate and precise.

# Unit Conversion and Conversion Factors

- Convert inches into centimeters
  1. Find relationship equivalence:  $1 \text{ in.} = 2.54 \text{ cm}$
  2. Write a conceptual plan



3. Change equivalence into conversion factors with starting units on the bottom

$$\frac{2.54 \text{ cm}}{1 \text{ in}}$$

Convert 30.0 mL to quarts (qt)

*(1 mL = 0.001 L; 1 L = 1.057 qt)*

How many cubic centimeters ( $\text{cm}^3$ ) are there in  $2.11 \text{ yd}^3$ ?  
( $1 \text{ yd} = 36 \text{ in.}$ ,  $1 \text{ in.} = 2.54 \text{ cm}$ )

# Density as a Conversion Factor

- **Can use density as a conversion factor between mass and volume!!**
  - density of H<sub>2</sub>O = 1.0 g/mL ∴ 1.0 g H<sub>2</sub>O = 1 mL H<sub>2</sub>O
  - density of Pb = 11.3 g/cm<sup>3</sup> ∴ 11.3 g Pb = 1 cm<sup>3</sup> Pb

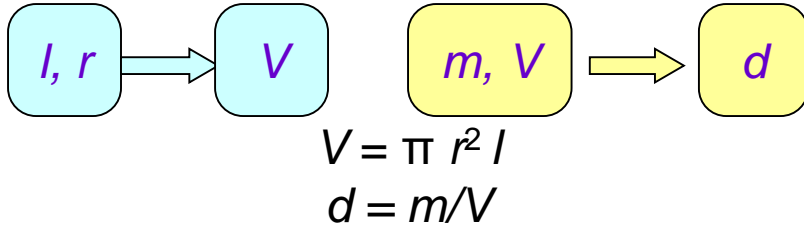
How much does 4.0 cm<sup>3</sup> of lead weigh?

$$4.0 \text{ cm}^3 \text{ Pb} \times \frac{11.3 \text{ g Pb}}{1 \text{ cm}^3 \text{ Pb}} = \underline{45.2} \text{ g Pb} = 45 \text{ g Pb}$$

# Calculate the Following

- How much does  $3.0 \times 10^2$  mL of ether weigh (g) ? ( $d = 0.71$  g/mL)
- What volume ( $\text{cm}^3$ ) does 100.0 g of marble occupy? ( $d = 4.0$  g/ $\text{cm}^3$ )

Find the density of a metal cylinder with mass 8.3 g, length 1.94 cm, and radius 0.55 cm



What is the mass in kilograms of a cube of lead that measures 0.12 m on each side?

( $d_{\text{Pb}} = 11.3 \text{ g/cm}^3$ )



# Homework

Chapter 1 HW

*Will be announced*