Measurements and Density

Physical and Chemical Properties of Matter

Physical Properties: No change to molecular composition

Changes are at the substance level: breaking glass

Phase changes: solid to liquid to gas etc.

ID without damage: Original compound can be recovered

Color, odor, solubility, density, molecular mass

Chemical Properties: Compositional changes to molecules

All chemical reactions: often called chemical change

Heat or light generated: Burning, decomposing

Original material changed on an atomic level

Molecules of original compound no longer present

Compound cannot be restored to its original form without another chemical change

Extensive and Intensive Properties

Extensive Property: Varies on amount of matter present

mass, length, volume, heat, intensity of color or odor

Intensive Property: Independent of amount of matter present

Temperature, boiling point, color, odor

Often a calculated ratio:

Density (mass/vol ratio)

Molar mass (grams/mol)

Can be used to identify a material

Scientific Notation

Displaying very large or small numbers

1700000 → 1.7×10^{6}

0.0000017 → 1.7×10^{-6}

2 parts: significant values & a multiplier

Significant: 17 for both values

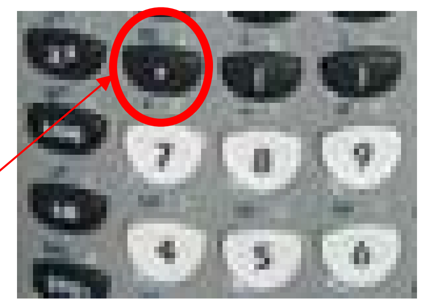
Multiplier: 100000 or 0.000001

Keep all significant numbers

Place decimal after 1st significant figure (1.7)

Multiplier used as exponent: 10^{x} or 10^{-x}

1700000 $= 1.7 \times 10^{6}$ 0.0000017 $= 1.7 \times 10^{-6}$



Use EXP, SCI or EE keys on calculator

Significant Figures: Number of Digits in Final Answer

1. All non-zero digits are significant

2. Use decimal point to determine significance of zeros

Between 2 numbers	significant	50.002	5
Before decimal point	not significant	0.502	3
Before the first digit	not significant	0.0052	2
End of # after decimal	significant	0.0200	3
No decimal point:	can't tell	500	?

3. Exact numbers have unlimited number of significant figures

Inherently an integer:	4 sides to a square
Inherently a fraction:	½ of a pie
Obtained by counting:	47 people in a class
Defined quantity:	12 eggs in a dozen

Determine the correct number of significant figures

(12.45 - 9.2680) x 3.575 = 9.71685

Addition/subtraction

(12.45 - 9.2680) = 3.182

2 sigfigs after decimal

3 sigfigs overall in final answer

Sigfigs based on decimal

```
  12.45XX
-  9.2680
   3.1820
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Multiplication/Division

3.182 x 3.575 = 9.71685

Use all significant digits

3 sigfigs in final answer

Addition limits sigfigs

Rounding

9.71685 = 9.72

round up 6>5

Based on number after sigfigs

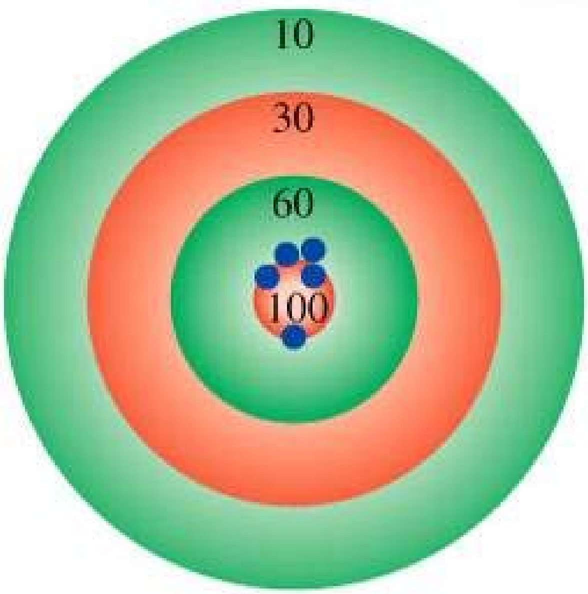
If < 5 Use number as written

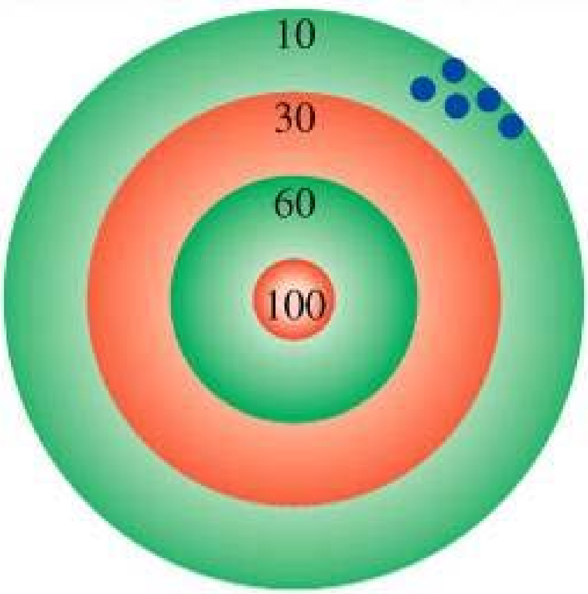
If $\geq$ 5 Round up 1 digit

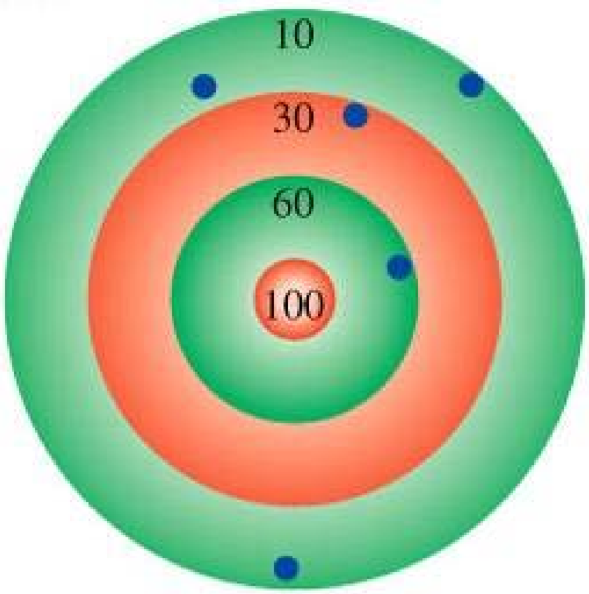
Precision and Accuracy

Accuracy – how close a measurement is to the true value

Precision – how close measurements are to each other







accurate
&
precise

precise
but
not accurate

not accurate
&
not precise

Deviation

Deviation = (experimental value – true* or average value)

Systematic:

Deviations in same direction, either all high or all low

Can often be minimized mathematically or eliminated

Measurement of accuracy

Random:

Deviations go both high and low

Cannot be eliminated mathematically

Need better data collection method with more sigfigs

Measurement of precision

*True or “real” value: Accepted or industry standard value

Percent Error and Percent Difference

Percent Error:

Measure of accuracy

Deviation: (experimental value- true value)

Percent Difference:

Measure of precision

Deviation: (experimental value – average value)

$$\% \text{ error} = \frac{|\text{Deviation}|}{\text{Real value}} \times 100 \qquad \% \text{ difference} = \frac{|\text{Deviation}|}{\text{Average value}} \times 100$$

Dimensional Analysis
Finding an answer by following units

How many kilograms of methanol will fill a 15.5 gallon fuel tank of a car modified to run on methanol?

Method:

1. What unit do you want to solve for? kilograms (kg)

2. What information do you need?

Data given in problem:	Volume = 15.5 gallons	
Data to look up:	Density of methanol= 0.791 g / mL	
	Gallon to Liter conversion: 1gal= 3.785L	
Data memorized:	1000mL = 1L	1000g = 1kg

3. Set up problem

$$\frac{kg}{1} = \frac{0.791g}{1ml} x \frac{1kg}{1000g} x \frac{1000mL}{L} x \frac{3.785L}{1gal} x \frac{15.5gal}{1} = 46.4kg$$

Base Units of Measurement International System of Units (SI)

Memorize Chart!

TABLE 1.2 SI Base Units

Base Quantity	Name of Unit	Symbol
Length	meter	m
Mass	kilogram	kg
Time	second	s
Electrical current	ampere	A
Temperature	kelvin	K
Amount of substance	mole	mol

SI Base Prefixes

Memorize Chart!

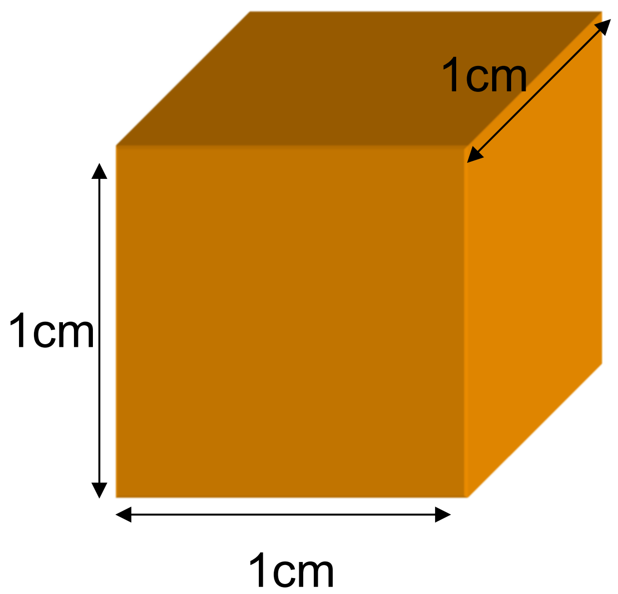
TABLE 1.3 Prefixes Used with SI Units

Prefix	Symbol	Meaning
tera-	T	1,000,000,000,000, or 10^{12}
giga-	G	1,000,000,000, or 10^{9}
mega-	M	1,000,000, or 10^{6}
kilo-	k	1,000, or 10^{3}
deci-	d	1/10, or 10^{-1}
centi-	c	1/100, or 10^{-2}
milli-	m	1/1,000, or 10^{-3}
micro-	μ	1/1,000,000, or 10^{-6}
nano-	n	1/1,000,000,000, or 10^{-9}
pico-	p	1/1,000,000,000,000, or 10^{-12}

Volume

SI derived unit for volume is a cubic meter (m^3)

Common unit is a “Liter (L)”



Defined exactly:

$1\ cm^3 = 1\ mL$

Density

Density: Ratio of mass to volume of a material

$$\text{density} = \frac{\text{mass}}{\text{volume}} = \frac{m}{V}$$

Substance	Density (g/cm^3)
Air*	0.001
Ethanol	0.79
Water	1.00
Mercury	13.6
Table salt	2.2
Iron	7.9
Gold	19.3

SI derived unit for density is kg/m^3

$1\ g/cm^3 = 1\ g/mL = 1000\ kg/m^3$

Intensive property
Can be used to identify a material
Units of mass and volume may vary
Often grams/mL or grams/cm^3

Concept Review Topics

1. Know terms given in the PowerPoint review and in the experiment.
2. Know difference between physical and chemical properties
3. Know difference between intensive and extensive properties
4. Reproduce calculations that were required to generate your results
5. Perform density calculations for both liquids and solids.
6. Understand the difference between percent error and percent difference and be able to calculate both values.
7. Show how to calculate a deviation and explain how the deviation of a series of measurements is related to a systematic vs. a random error.
8. Be able to calculate significant figures correctly.
9. Understand the concepts of accuracy and precision
10. Use dimensional analysis to solve density problems.