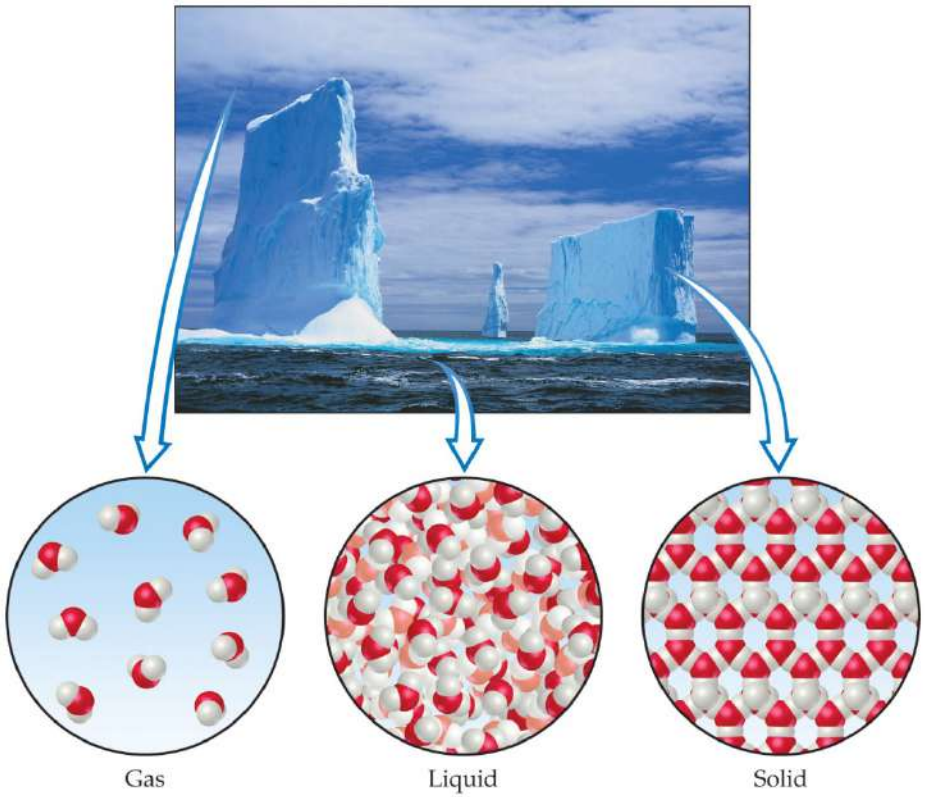
Chemistry, The Central Science, 11th edition
Theodore L. Brown; H. Eugene LeMay, Jr.;
and Bruce E. Bursten

Chapter 1
Introduction:
Matter and Measurement

John D. Bookstaver
St. Charles Community College
Cottleville, MO

Chemistry

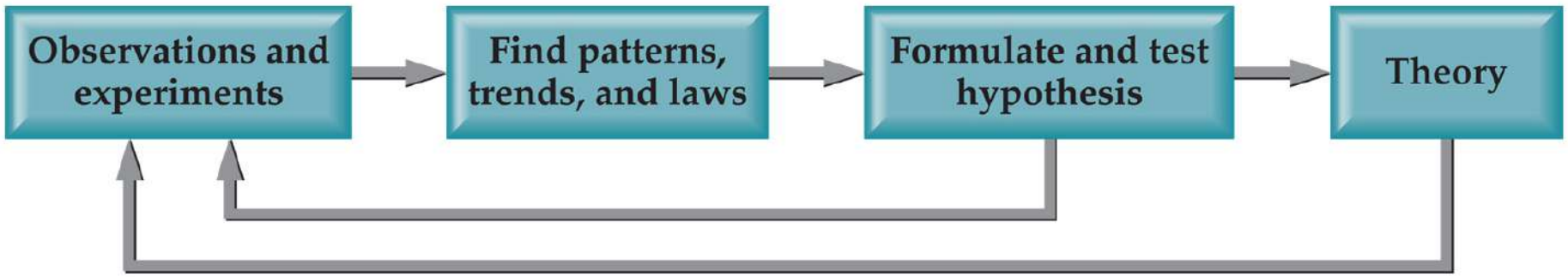


In this science we study matter and the changes it undergoes.

Matter And Measurement

Scientific Method

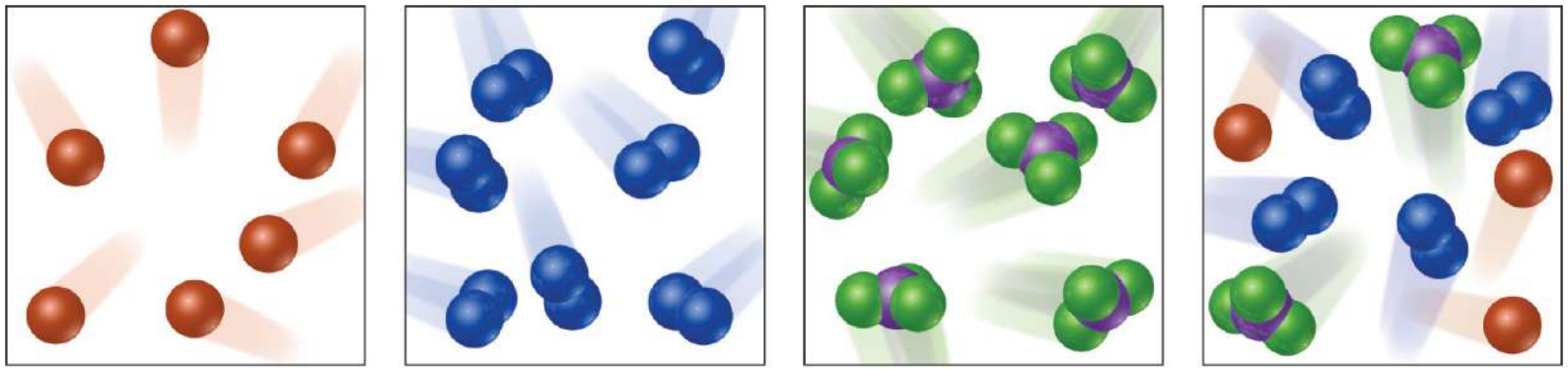
The scientific method is simply a systematic approach to solving problems.



Matter And Measurement

Matter

We define matter as anything that has mass and takes up space.



(a) Atoms of an element

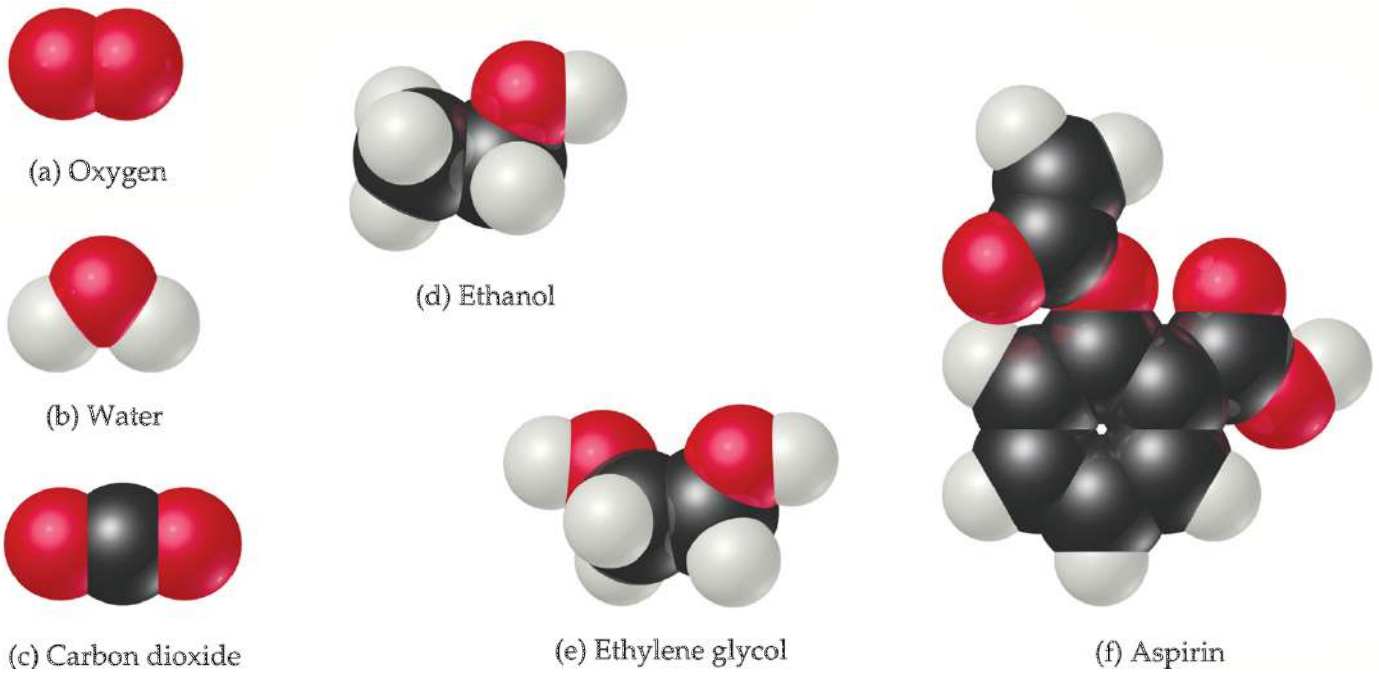
(b) Molecules of an element

(c) Molecules of a compound

(d) Mixture of elements and a compound

Matter And Measurement

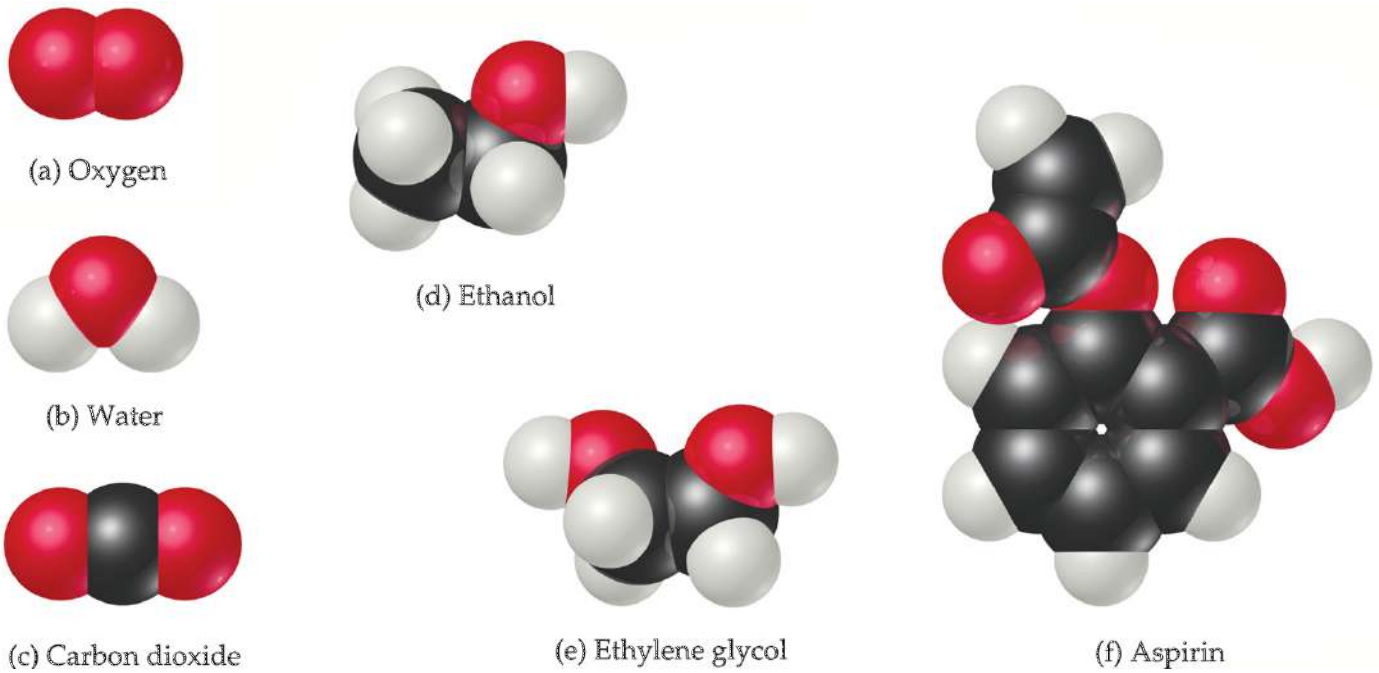
Matter



- Atoms are the building blocks of matter.

Matter And Measurement

Matter



- Atoms are the building blocks of matter.
- Each element is made of the same kind of atom.

Matter And Measurement

Matter

(a) Oxygen

(b) Water

(c) Carbon dioxide

(d) Ethanol

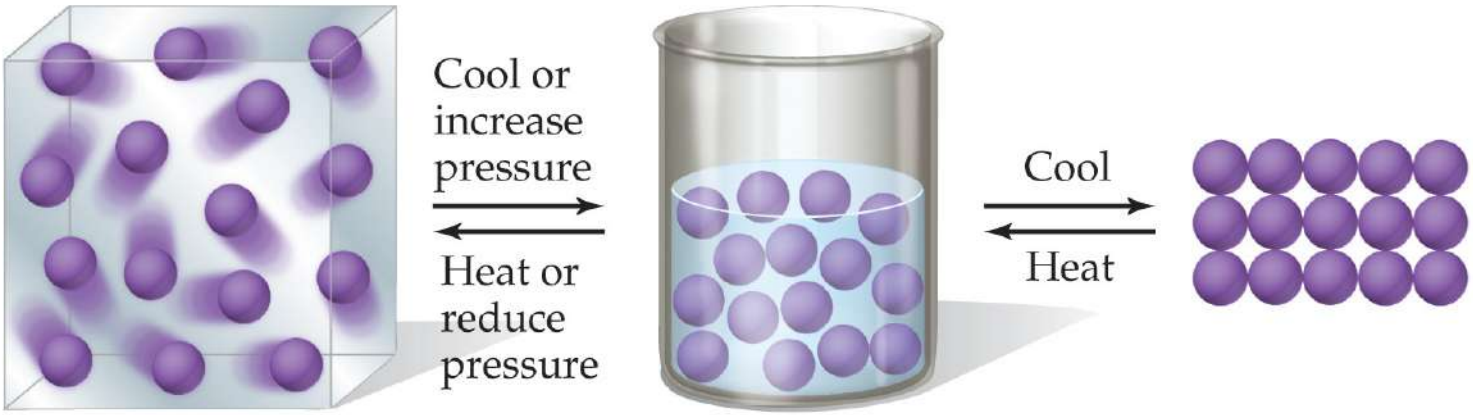
(e) Ethylene glycol

(f) Aspirin

- Atoms are the building blocks of matter.
- Each element is made of the same kind of atom.
- A compound is made of two or more different kinds of elements.

Matter And Measurement

States of Matter



Gas

Total disorder; much empty space; particles have complete freedom of motion; particles far apart

Liquid

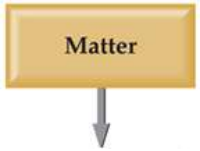
Disorder; particles or clusters of particles are free to move relative to each other; particles close together

Crystalline solid

Ordered arrangement; particles are essentially in fixed positions; particles close together

Matter And Measurement

Classification of Matter

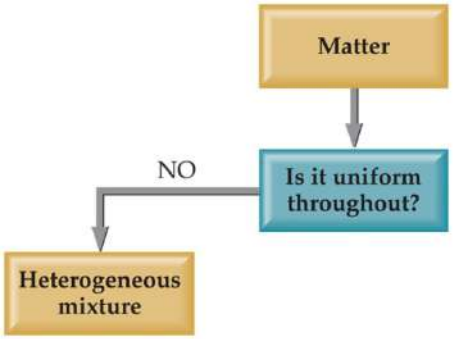


Matter And Measurement

Classification of Matter

Matter And Measurement

Classification of Matter



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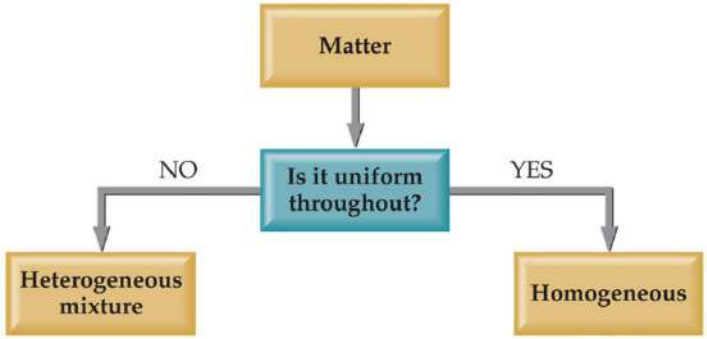

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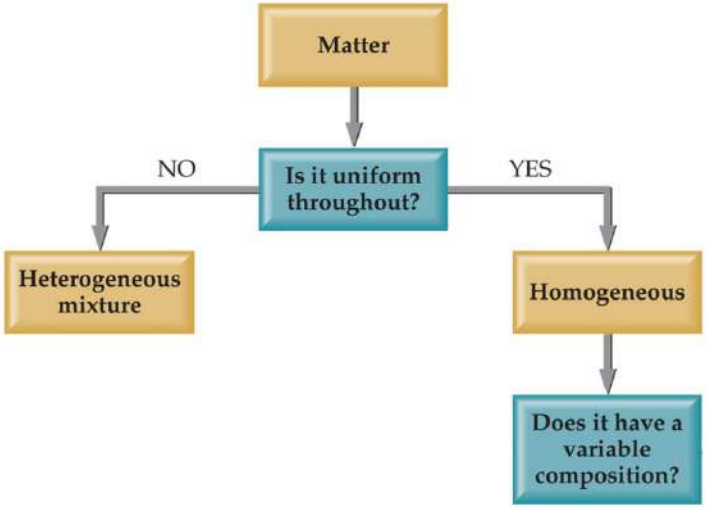

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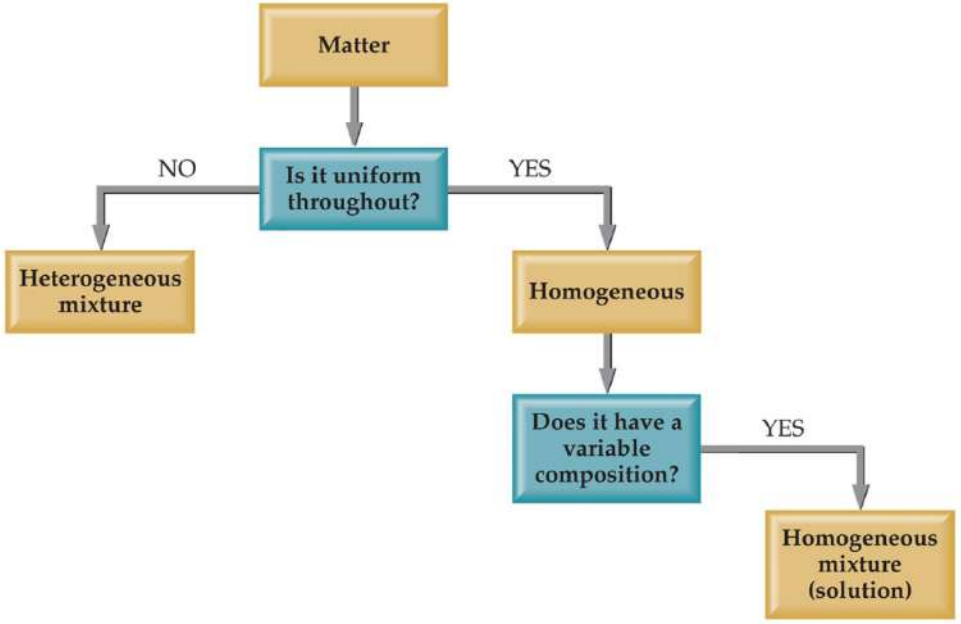

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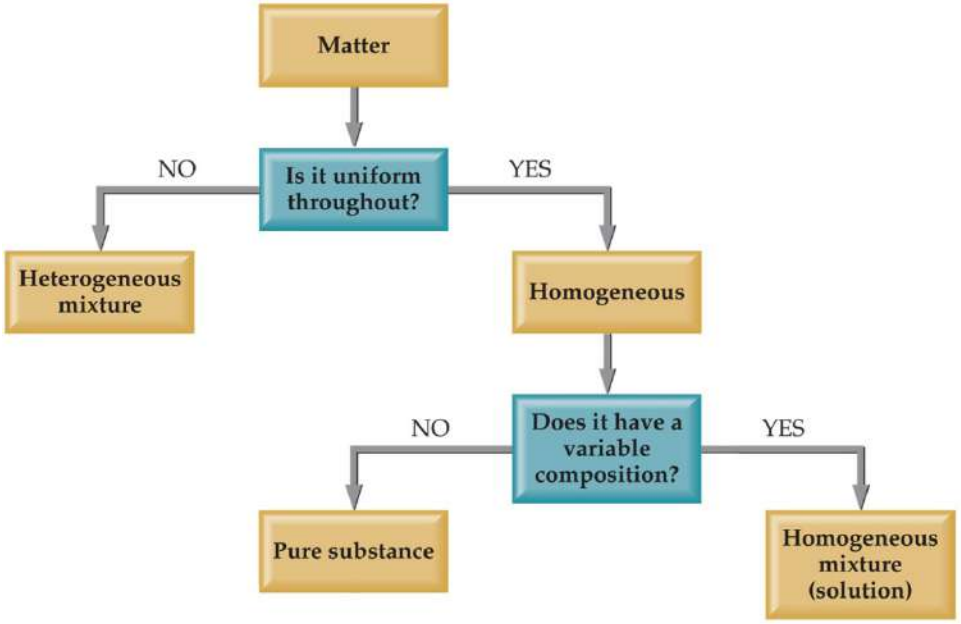

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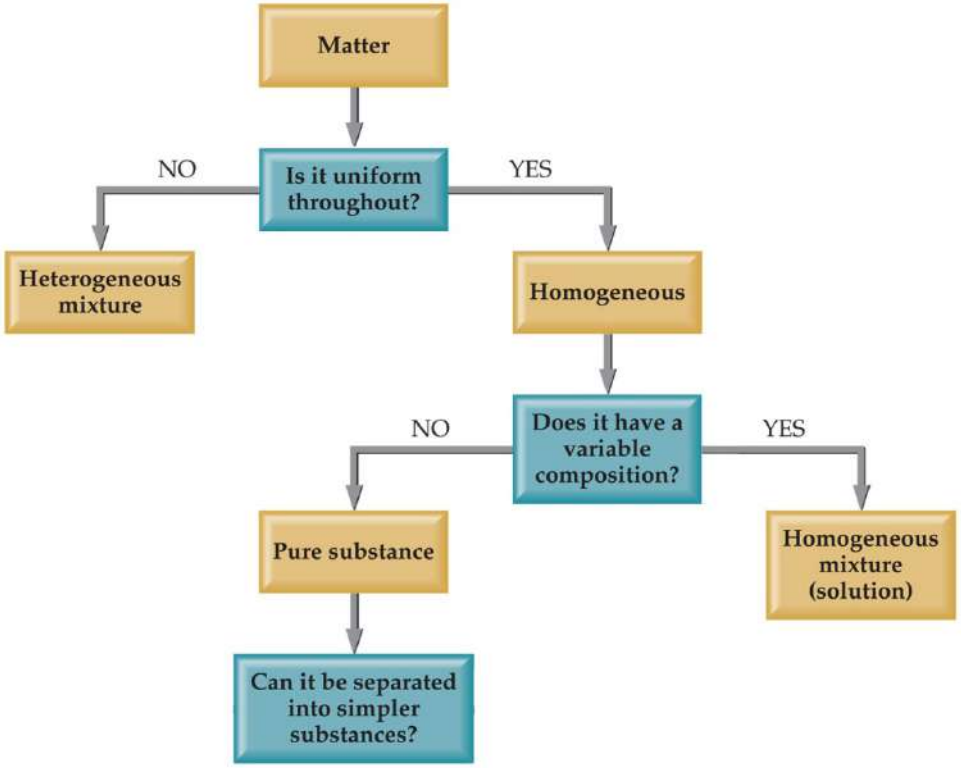

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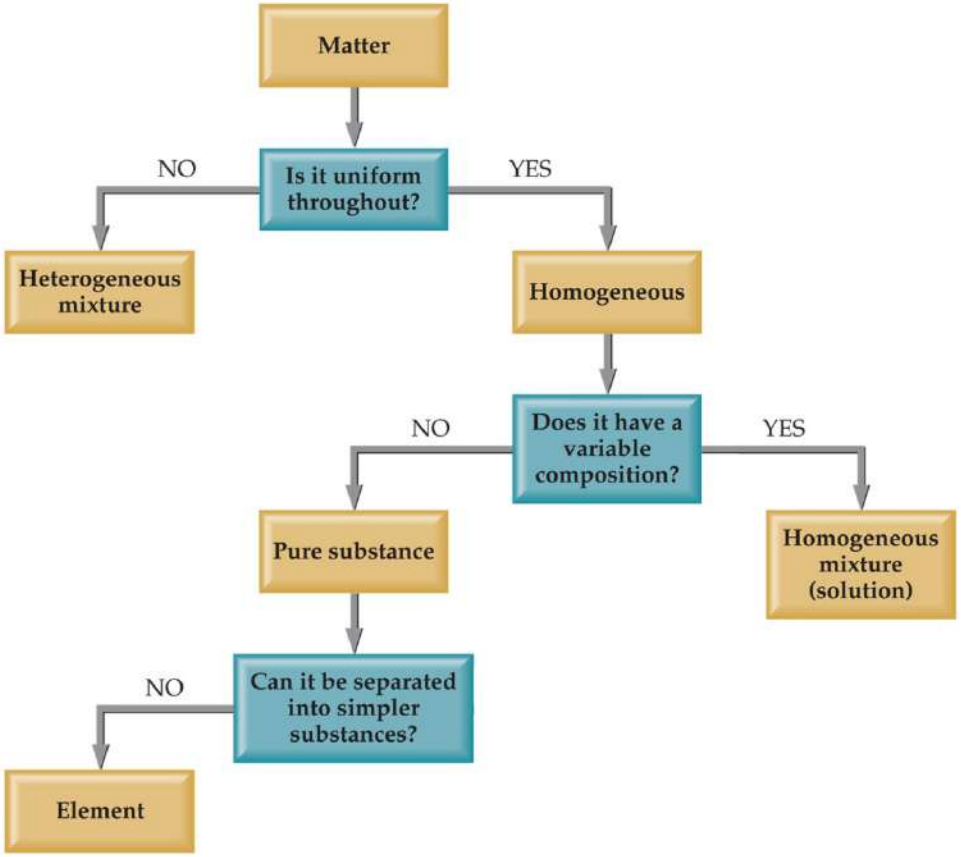

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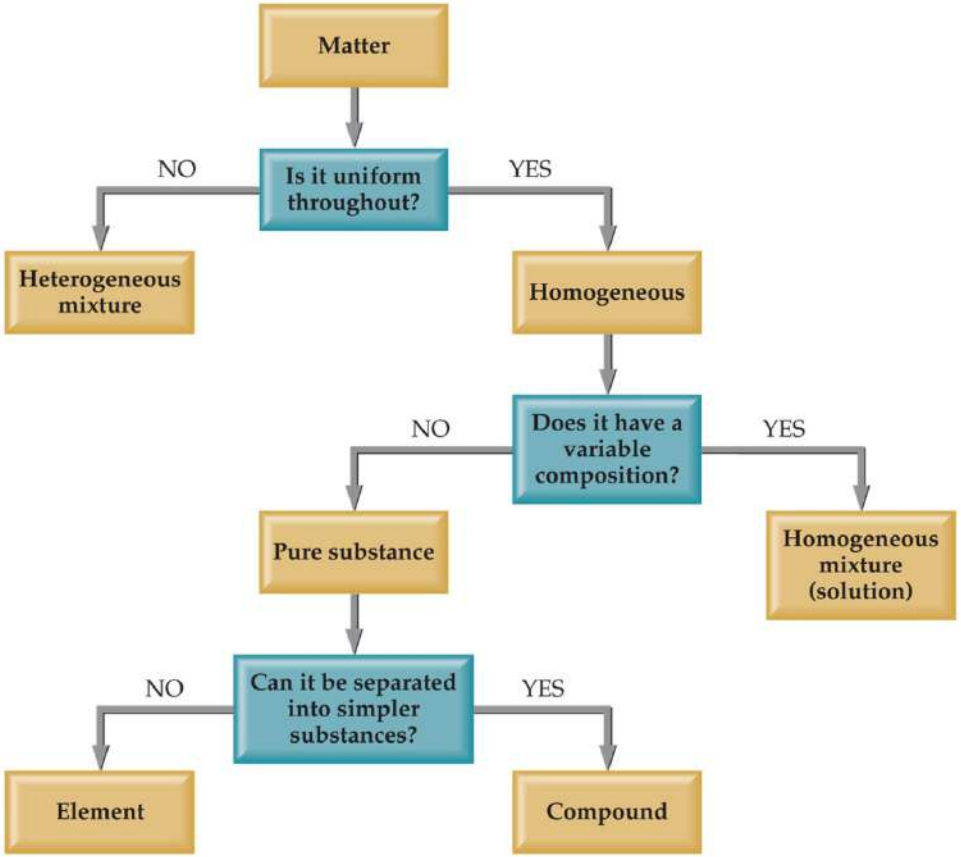
Classification of Matter



Matter And Measurement

Properties and Changes of Matter

Types of Properties

- Physical Properties…
  - Can be observed without changing a substance into another substance.
    - Boiling point, density, mass, volume, etc.
- Chemical Properties…
  - Can *only* be observed when a substance is changed into another substance.
    - Flammability, corrosiveness, reactivity with acid, etc.

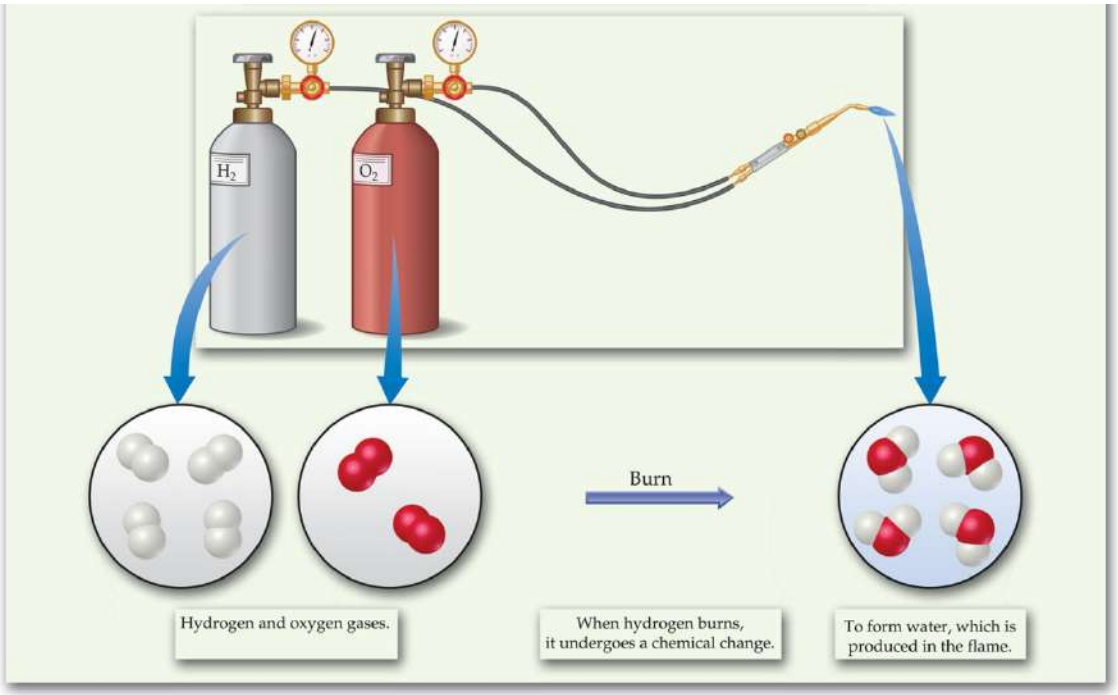
Types of Properties

- Intensive Properties…
  - Are independent of the amount of the substance that is present.
    - Density, boiling point, color, etc.
- Extensive Properties…
  - Depend upon the amount of the substance present.
    - Mass, volume, energy, etc.

Types of Changes

- Physical Changes
  - These are changes in matter that do not change the composition of a substance.
    - Changes of state, temperature, volume, etc.
- Chemical Changes
  - Chemical changes result in new substances.
    - Combustion, oxidation, decomposition, etc.

Chemical Reactions

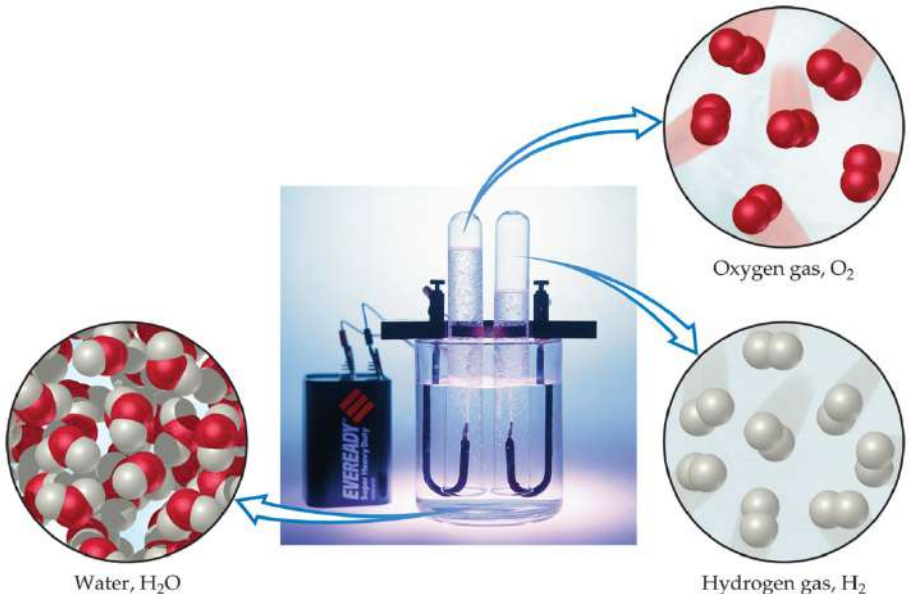


In the course of a chemical reaction, the reacting substances are converted to new substances.

Matter And Measurement

Compounds

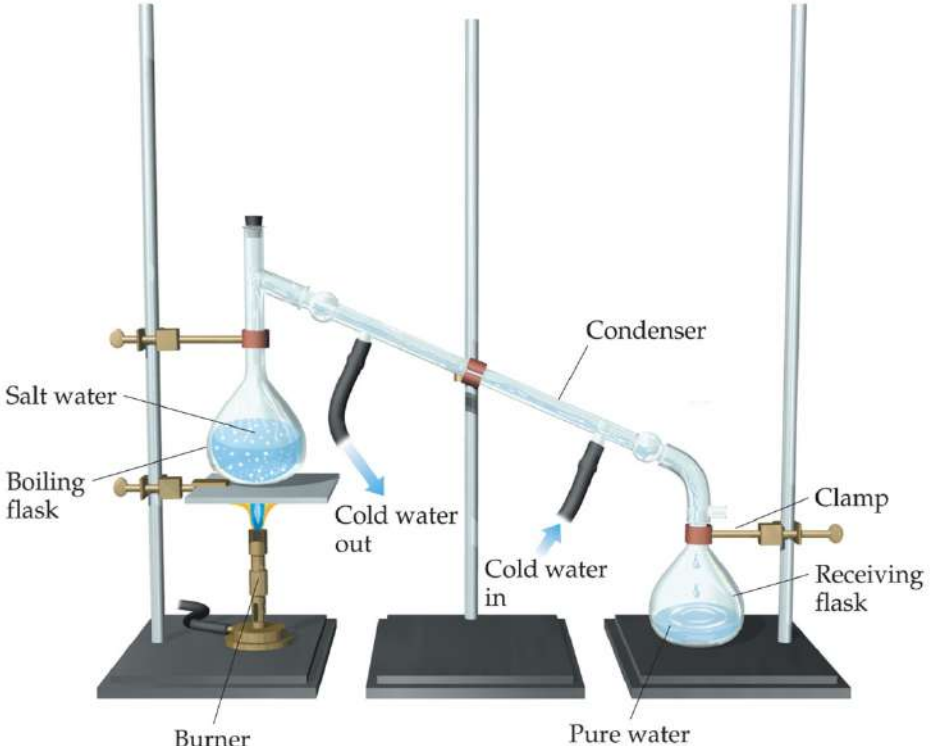
Compounds can be broken down into more elemental particles.



Matter And Measurement

Separation of Mixtures

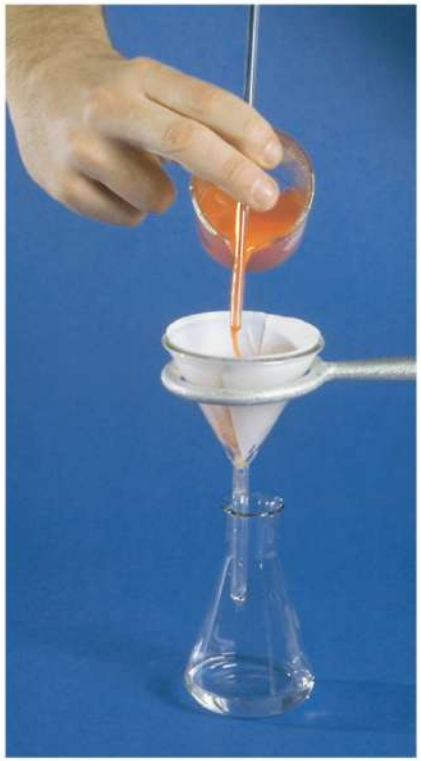
Distillation



Distillation uses differences in the boiling points of substances to separate a homogeneous mixture into its components.

Matter And Measurement

Filtration



In filtration solid substances are separated from liquids and solutions.

Matter And Measurement

Chromatography

This technique separates substances on the basis of differences in solubility in a solvent.

Matter And Measurement

Units of Measurement

SI Units

Physical Quantity	Name of Unit	Abbreviation
Mass	Kilogram	kg
Length	Meter	m
Time	Second	s[a]
Temperature	Kelvin	K
Amount of substance	Mole	mol
Electric current	Ampere	A
Luminous intensity	Candela	cd

[a]The abbreviation sec is frequently used.

- *Système International d'Unités*
- A different base unit is used for each quantity.

Metric System

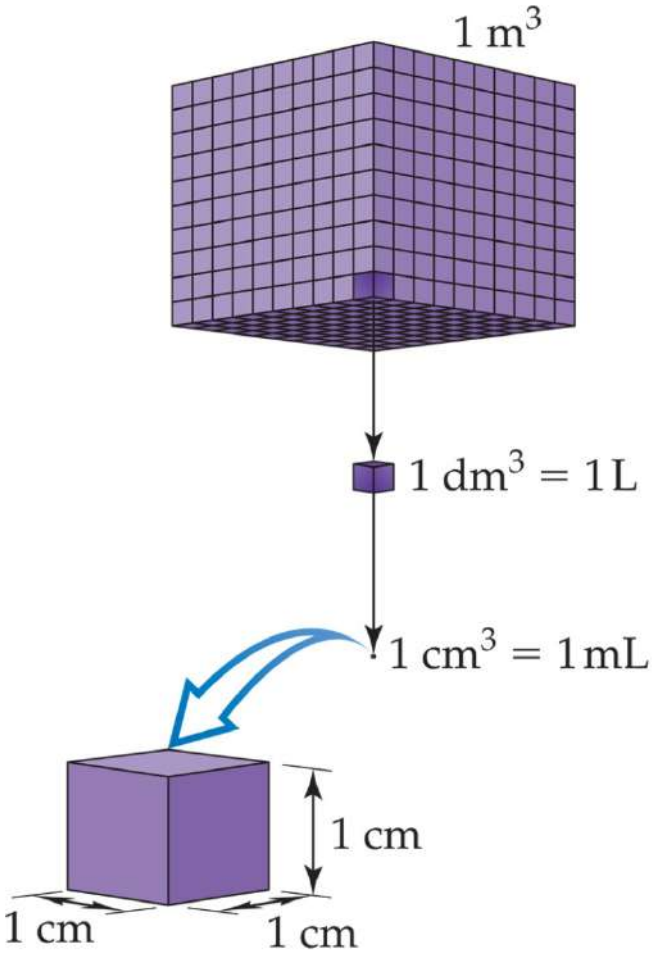
Prefixes convert the base units into units that are appropriate for the item being measured.

Prefix	Abbreviation	Meaning	Example
Giga	G	10^9	1 gigameter (Gm) = 1×10^9 m
Mega	M	10^6	1 megameter (Mm) = 1×10^6 m
Kilo	k	10^3	1 kilometer (km) = 1×10^3 m
Deci	d	10^{-1}	1 decimeter (dm) = 0.1 m
Centi	c	10^{-2}	1 centimeter (cm) = 0.01 m
Milli	m	10^{-3}	1 millimeter (mm) = 0.001 m
Micro	μ[a]	10^{-6}	1 micrometer (μm) = 1×10^{-6} m
Nano	n	10^{-9}	1 nanometer (nm) = 1×10^{-9} m
Pico	p	10^{-12}	1 picometer (pm) = 1×10^{-12} m
Femto	f	10^{-15}	1 femtometer (fm) = 1×10^{-15} m

[a]This is the Greek letter mu (pronounced "mew").

Volume

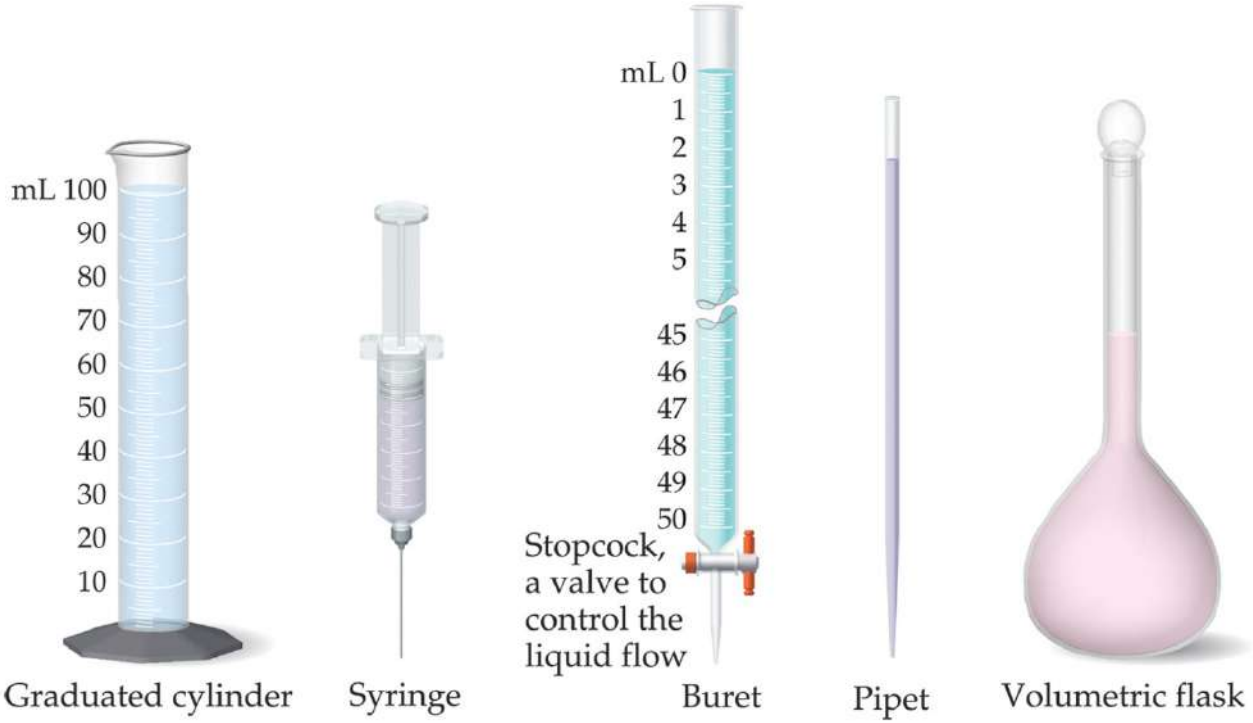
- The most commonly used metric units for volume are the liter (L) and the milliliter (mL).
  - A liter is a cube 1 dm long on each side.
  - A milliliter is a cube 1 cm long on each side.



Matter And Measurement

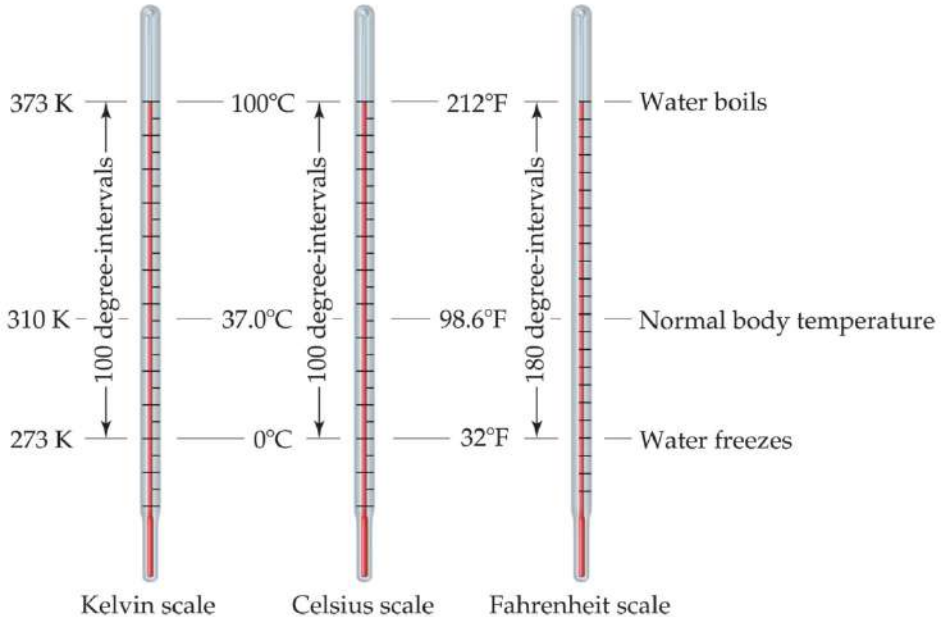
Uncertainty in Measurements

Different measuring devices have different uses and different degrees of accuracy.



Matter And Measurement

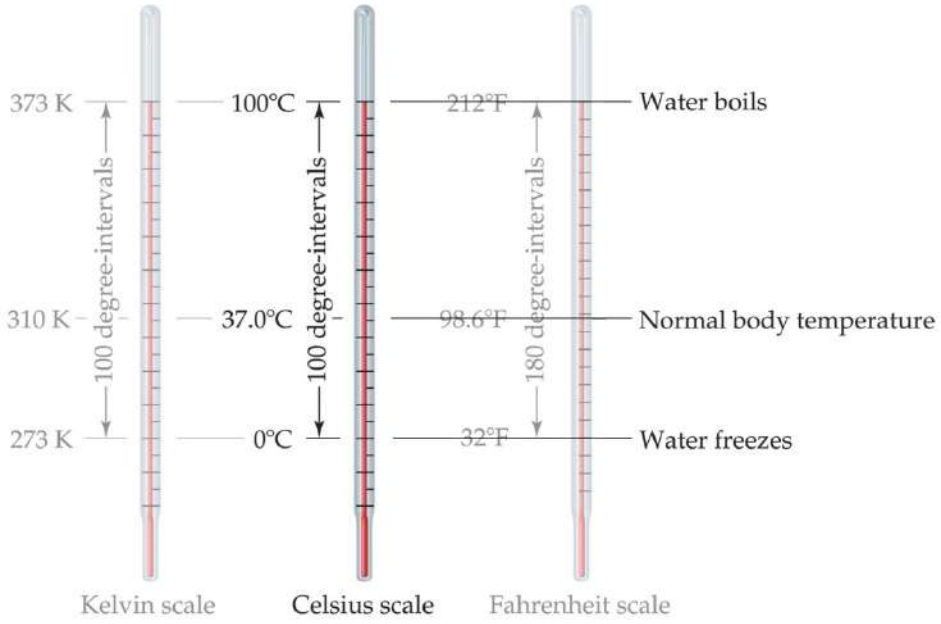
Temperature



By definition temperature is a measure of the average kinetic energy of the particles in a sample.

Matter And Measurement

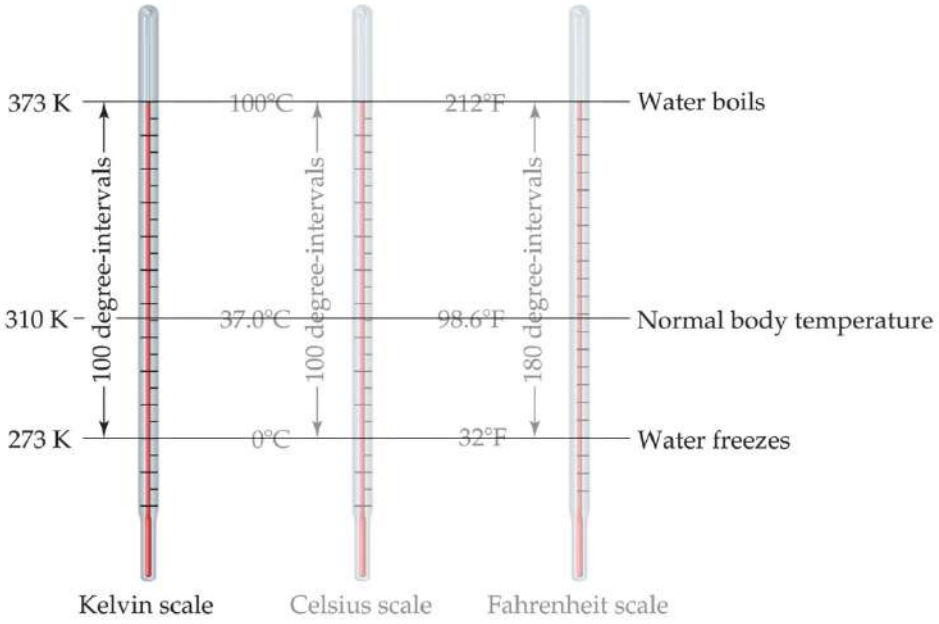
Temperature



- In scientific measurements, the Celsius and Kelvin scales are most often used.
- The Celsius scale is based on the properties of water.
  - 0°C is the freezing point of water.
  - 100°C is the boiling point of water.

Matter And Measurement

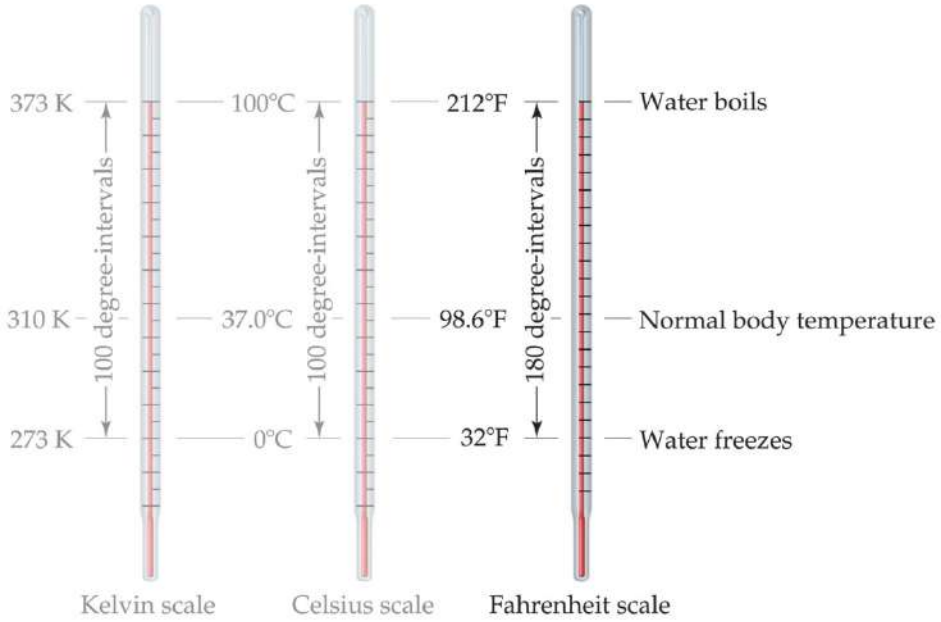
Temperature



- The Kelvin is the SI unit of temperature.
- It is based on the properties of gases.
- There are no negative Kelvin temperatures.
- $K = °C + 273.15$

Matter And Measurement

Temperature



- The Fahrenheit scale is not used in scientific measurements.
- °F = 9/5(°C) + 32
- °C = 5/9(°F − 32)

Matter And Measurement

Density

Density is a physical property of a substance.

$$d = \frac{m}{V}$$

Uncertainty in Measurement

Significant Figures

- The term significant figures refers to digits that were measured.
- When rounding calculated numbers, we pay attention to significant figures so we do not overstate the accuracy of our answers.

Significant Figures

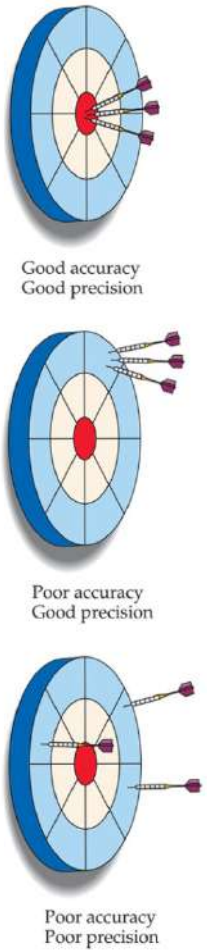
1. All nonzero digits are significant.
2. Zeroes between two significant figures are themselves significant.
3. Zeroes at the beginning of a number are never significant.
4. Zeroes at the end of a number are significant if a decimal point is written in the number.

Significant Figures

- When addition or subtraction is performed, answers are rounded to the least significant decimal place.
- When multiplication or division is performed, answers are rounded to the number of digits that corresponds to the *least* number of significant figures in any of the numbers used in the calculation.

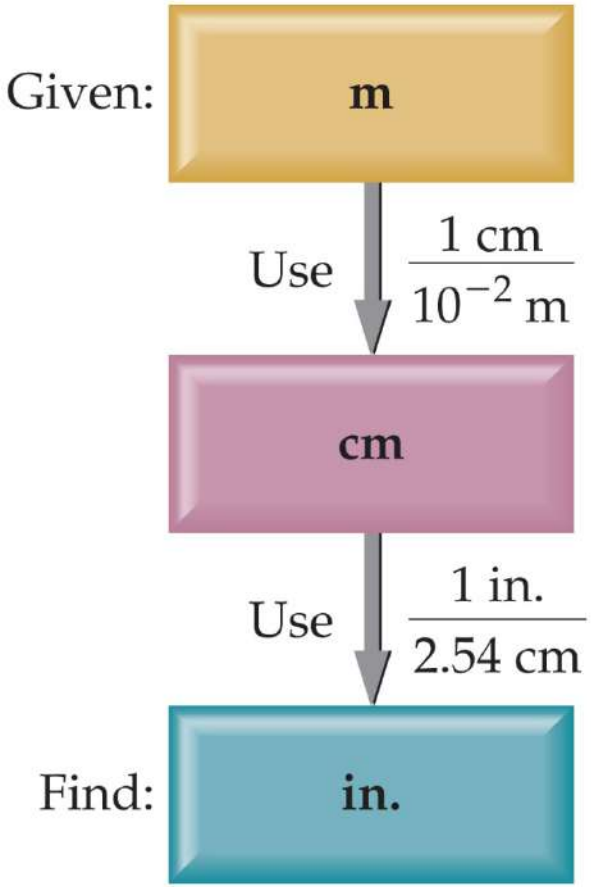
Accuracy versus Precision

- **Accuracy** refers to the proximity of a measurement to the true value of a quantity.
- **Precision** refers to the proximity of several measurements to each other.



Matter And Measurement

Dimensional Analysis



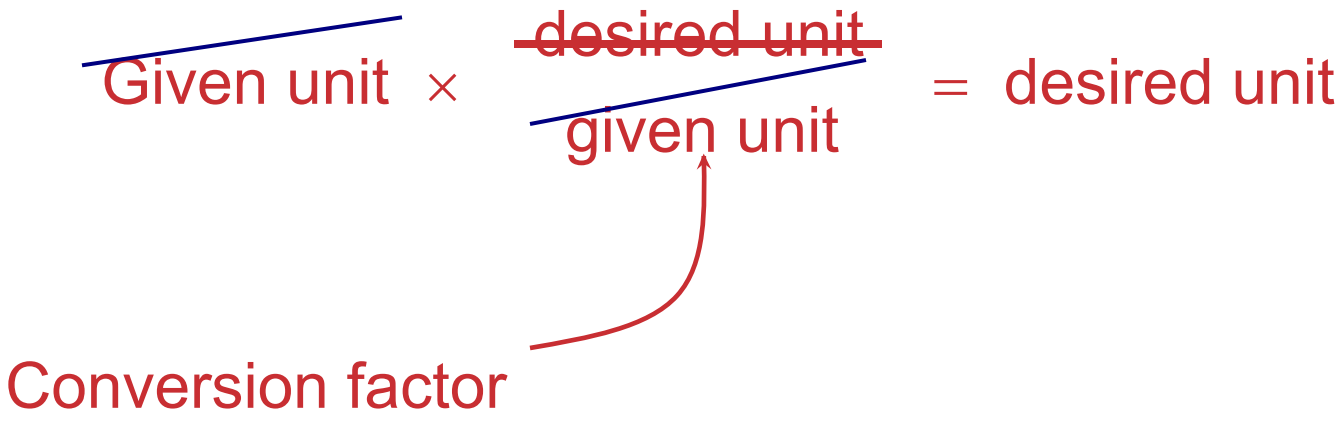
- We use dimensional analysis to convert one quantity to another.
- Most commonly dimensional analysis utilizes conversion factors (e.g., 1 in. = 2.54 cm)

$$\frac{1\text{ in.}}{2.54\text{ cm}} \quad \text{or} \quad \frac{2.54\text{ cm}}{1\text{ in.}}$$

Matter And Measurement

Dimensional Analysis

Use the form of the conversion factor that puts the sought-for unit in the numerator.



Dimensional Analysis

- For example, to convert 8.00 m to inches,
  - convert m to cm
  - convert cm to in.

$$8.00\ \text{m} \times \frac{100\ \text{cm}}{1\ \text{m}} \times \frac{1\ \text{in.}}{2.54\ \text{cm}} = 315\ \text{in.}$$

Matter And Measurement