Chemistry, The Central Science, 10th edition

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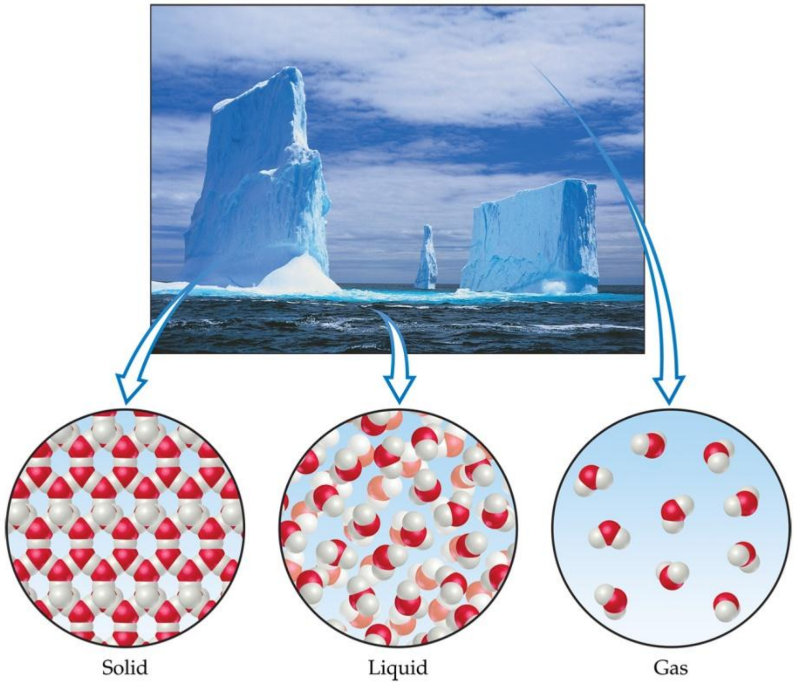
and Bruce E. Bursten

Chapter 1
Introduction:
Matter and Measurement

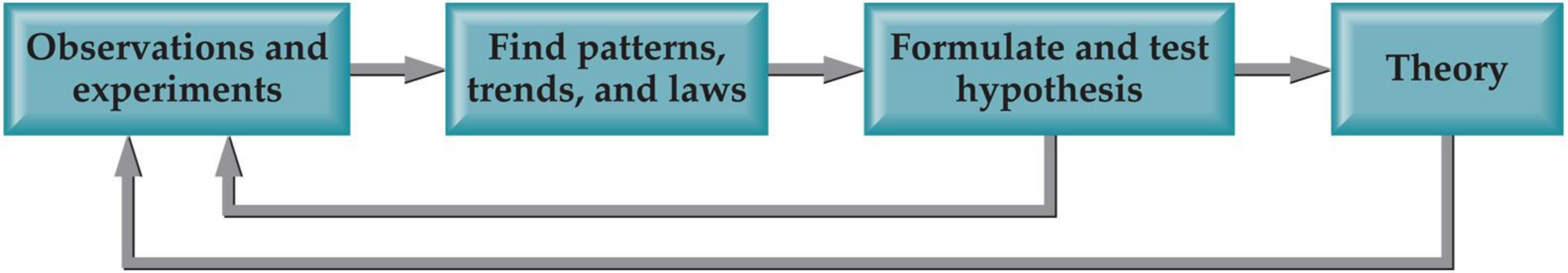
Chemistry:



The study of matter and the changes it undergoes.

Scientific Method:

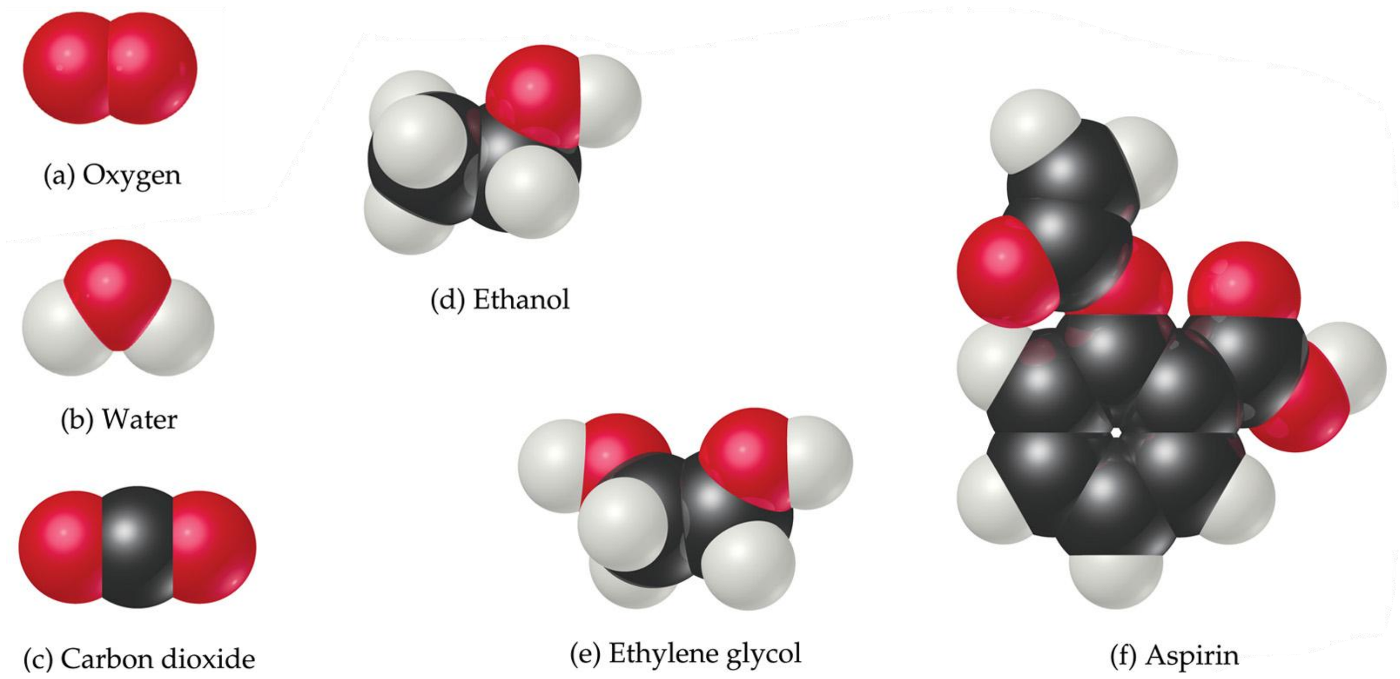
A systematic approach to solving problems.



Matter:

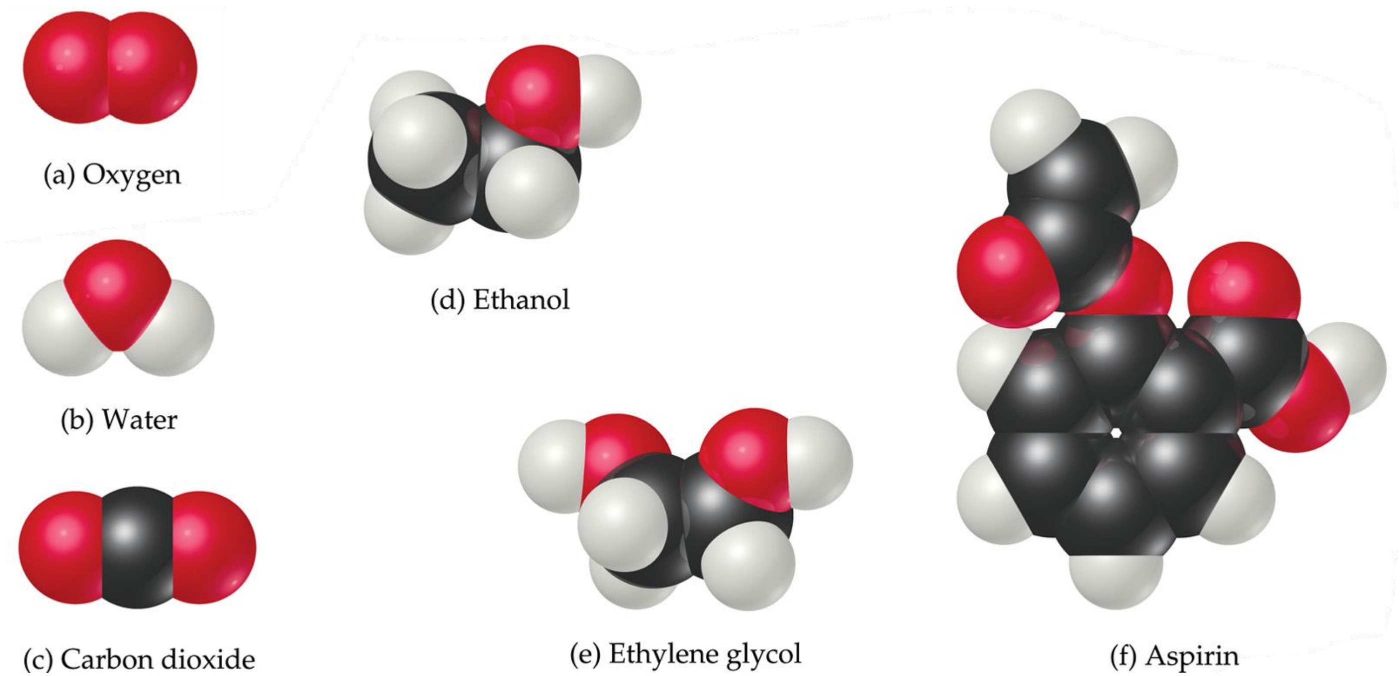
Anything that has mass and takes up space.

Matter



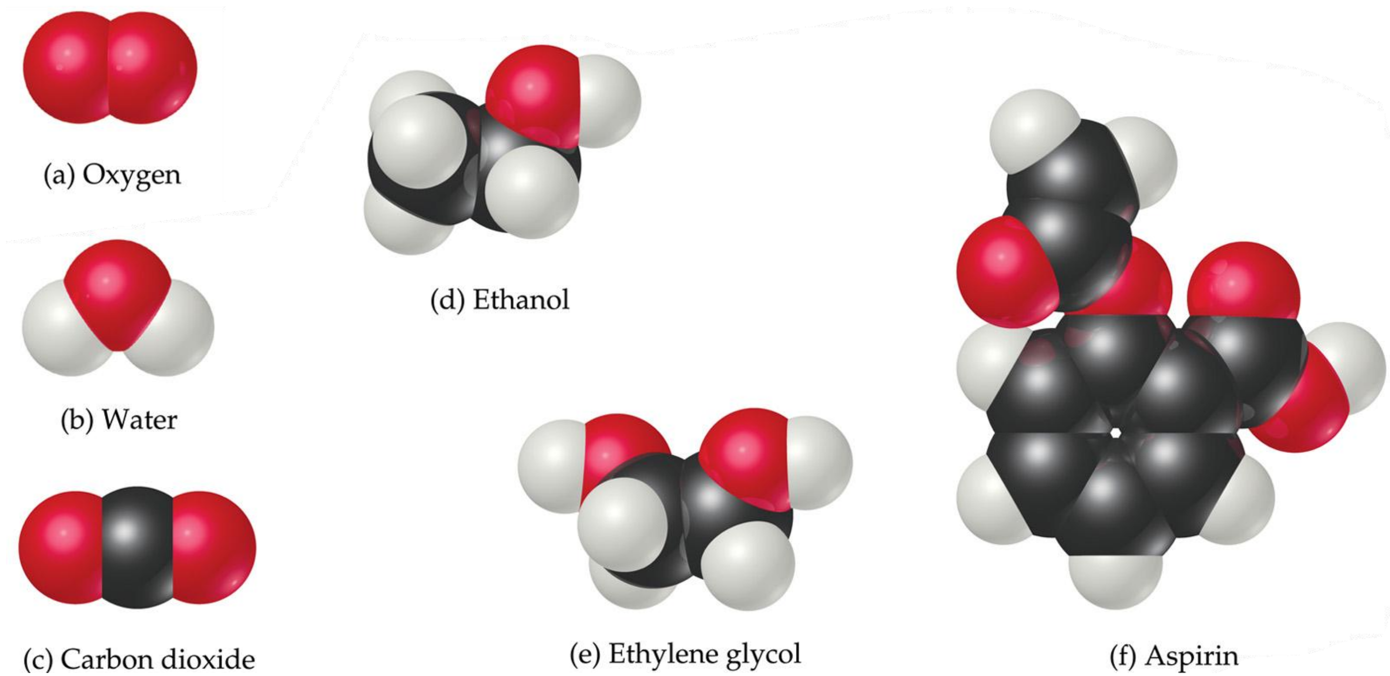
- Atoms are the building blocks of matter.

Matter



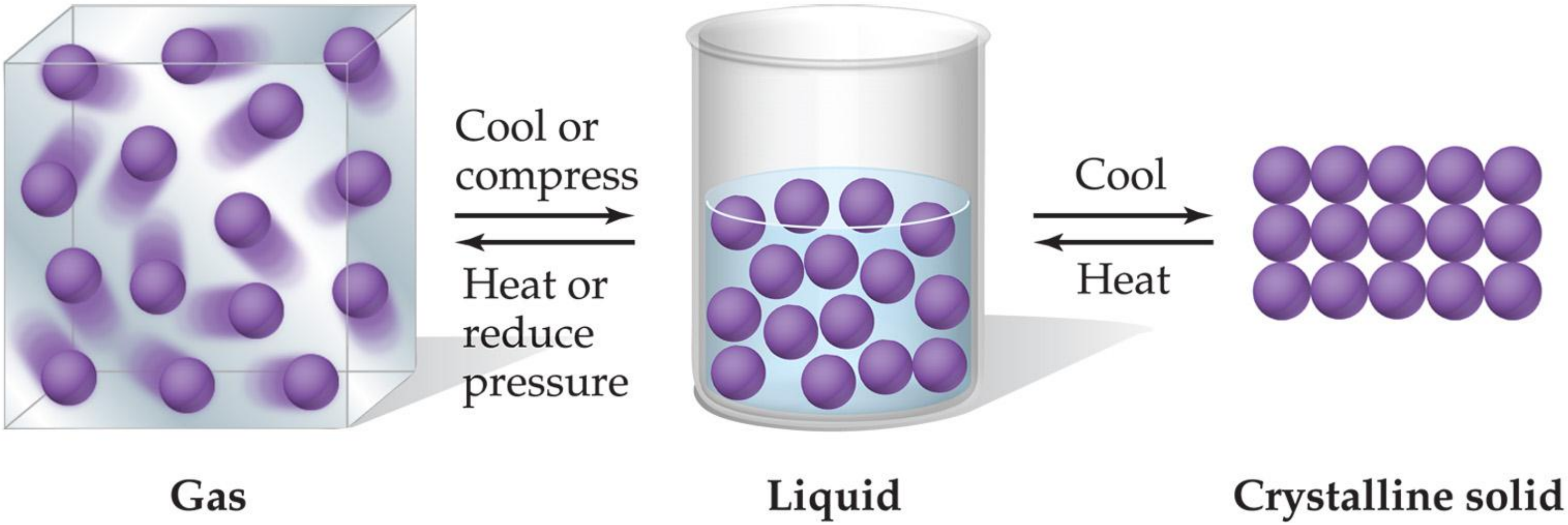
- Atoms are the building blocks of matter.
- Each element is made of the same kind of atom.

Matter

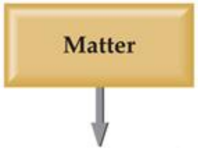


- Atoms are the building blocks of matter.
- Each element is made of the same kind of atom.
- A compound is made of two or more different kinds of elements.

States of Matter



Classification of Matter



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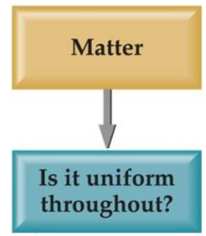

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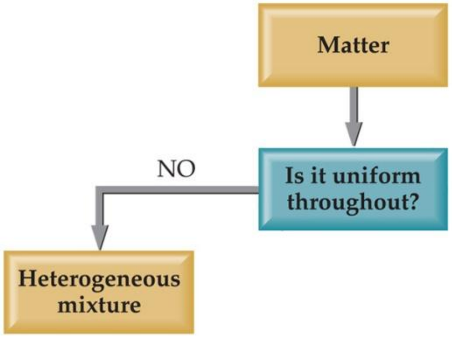
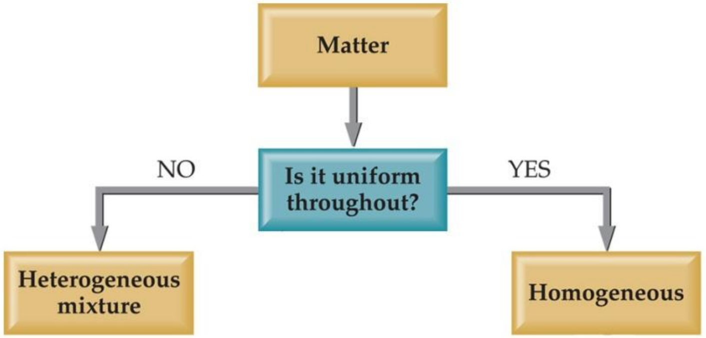
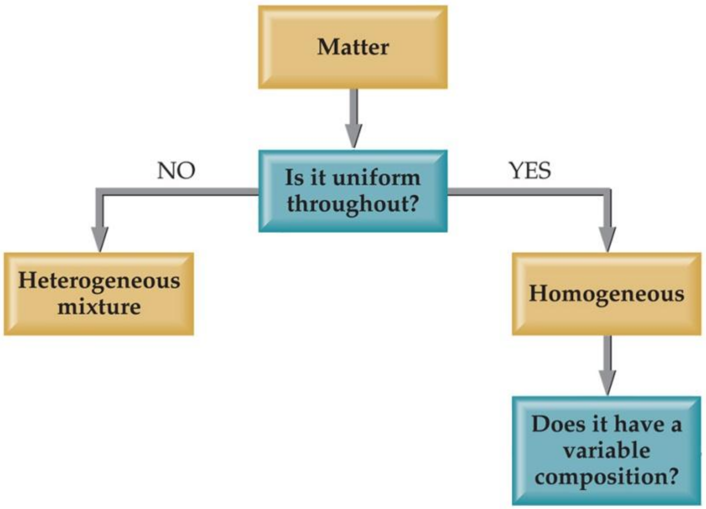


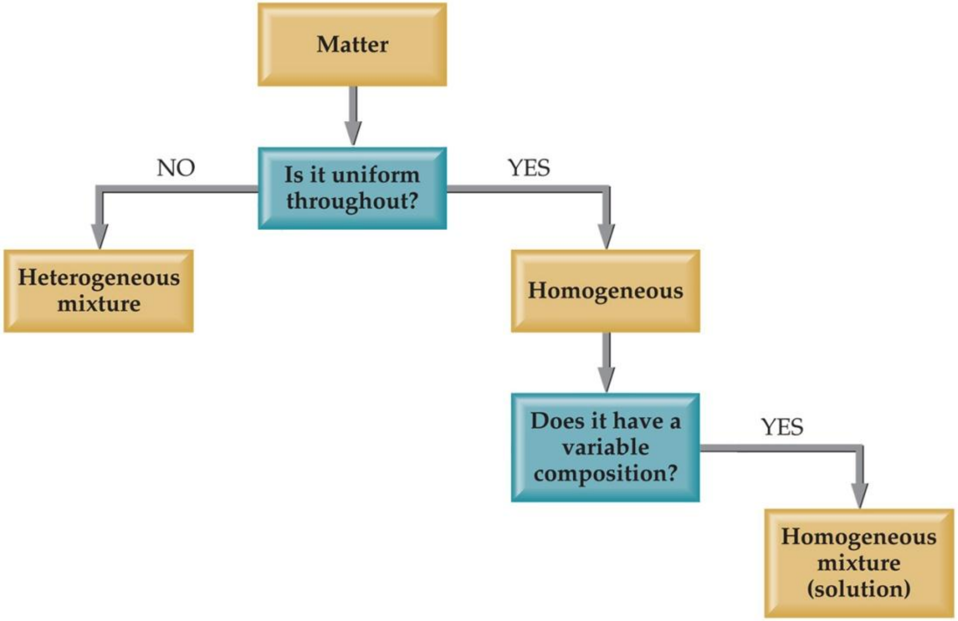
Classification of Matter



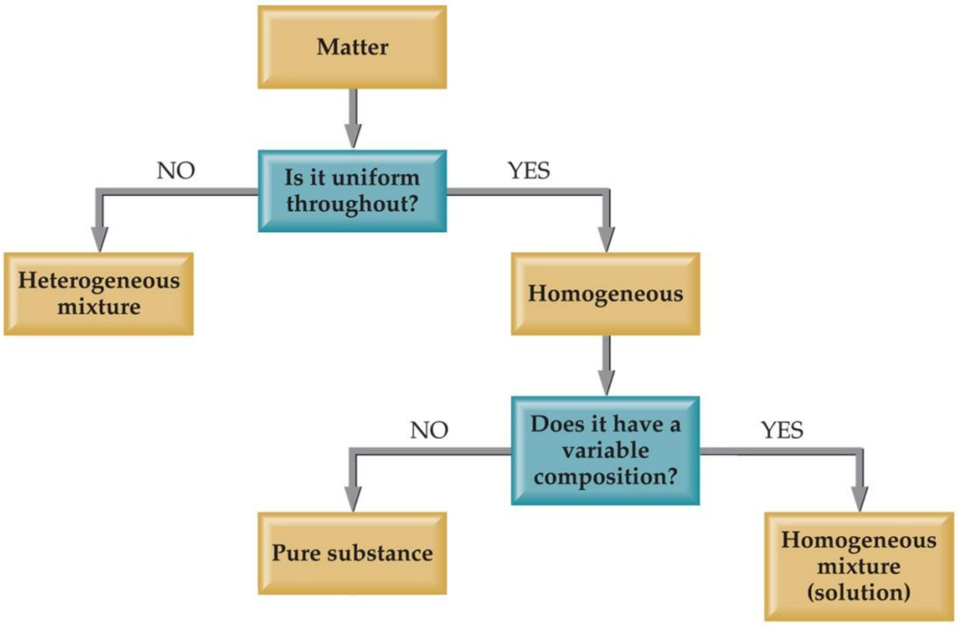
Classification of Matter



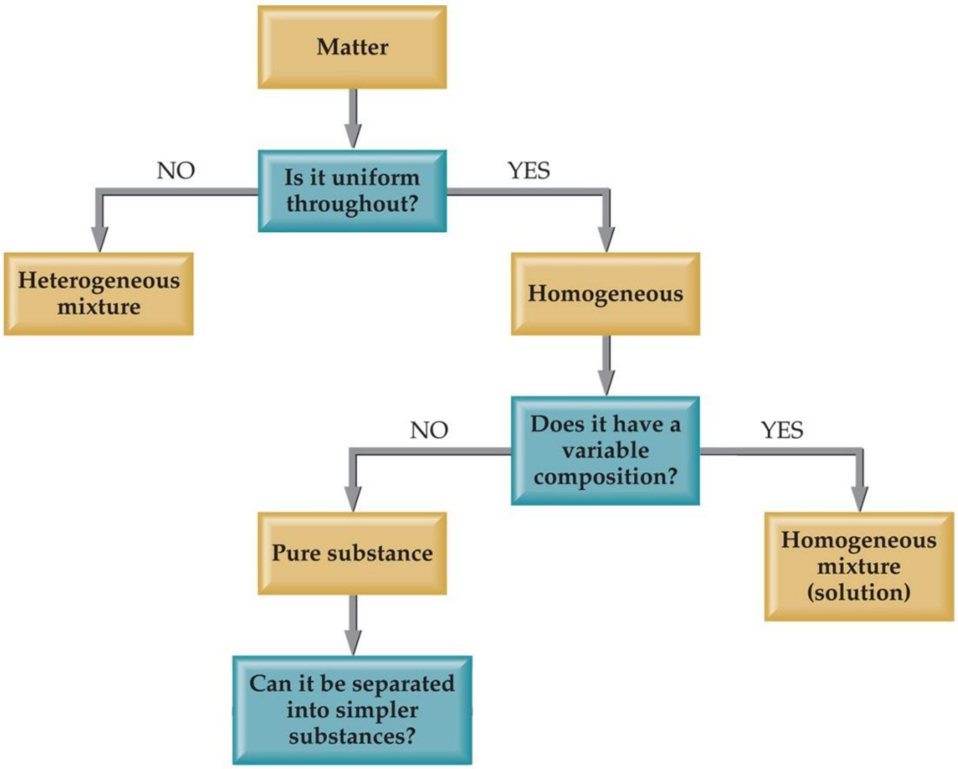
Classification of Matter



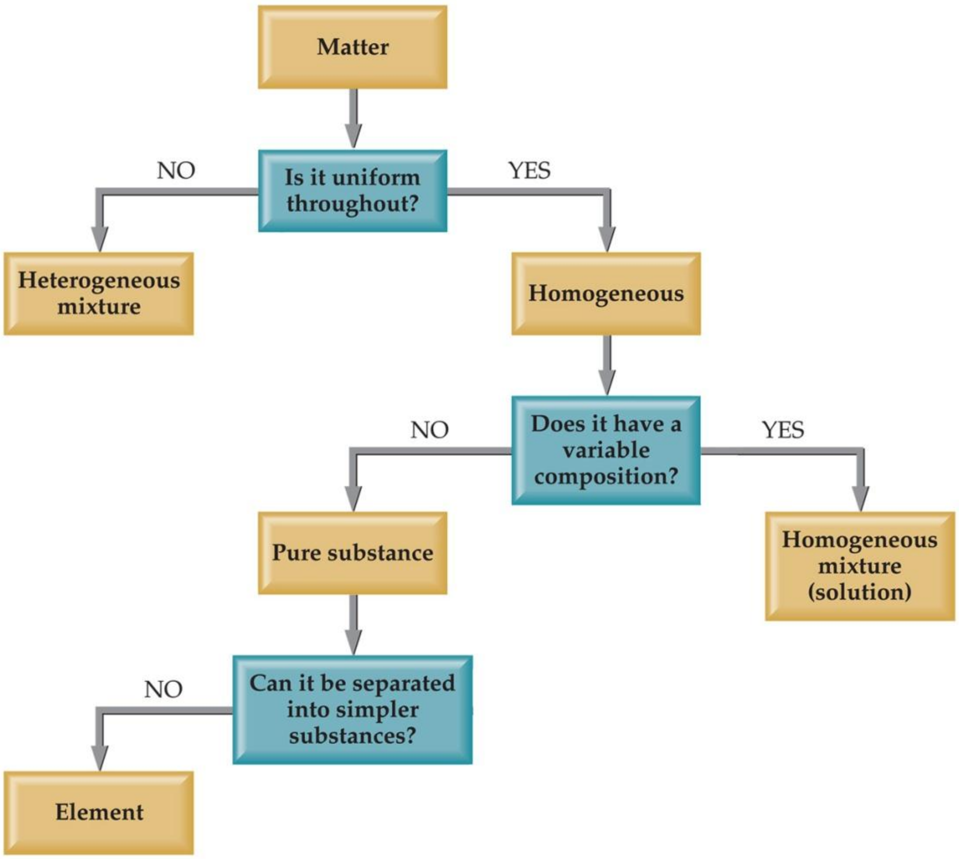
Classification of Matter



Classification of Matter



Classification of Matter



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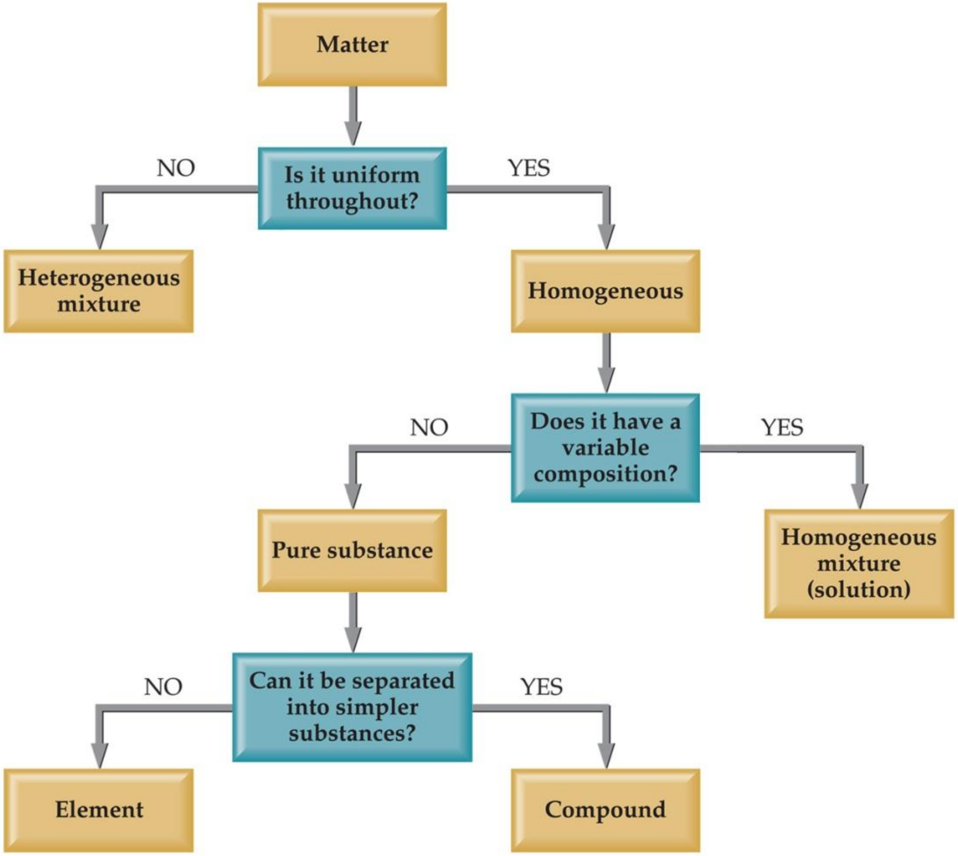
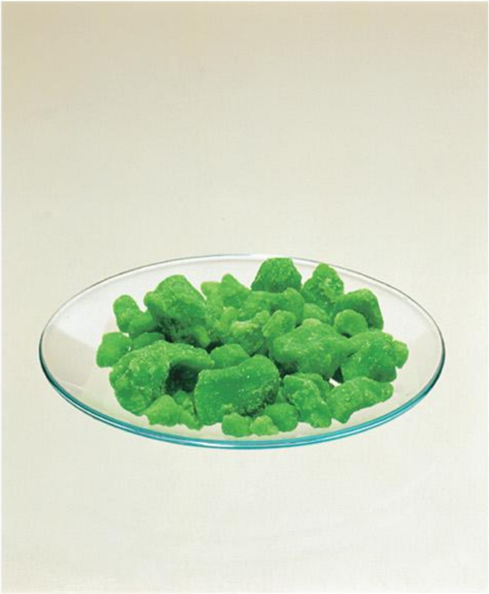


Mixtures and Compounds



Properties and Changes of Matter

Properties of Matter

- 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.

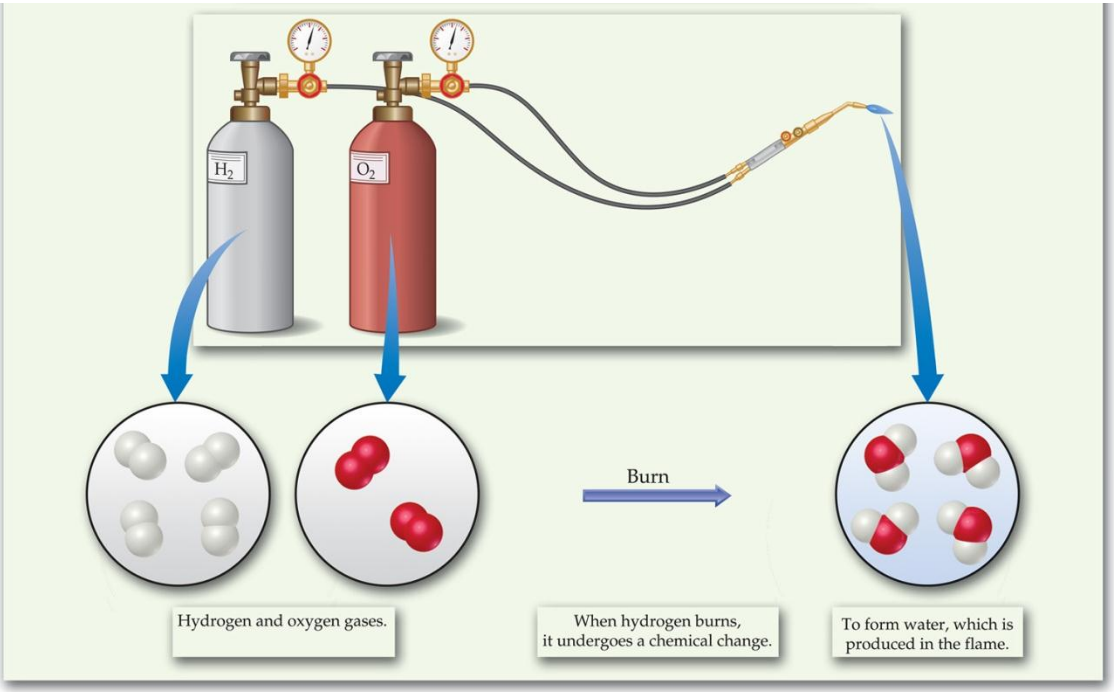
Properties of Matter

- Intensive Properties:
  - □ Independent of the amount of the substance that is present.
    - Density, boiling point, color, etc.
- Extensive Properties:
  - □ Dependent upon the amount of the substance present.
    - Mass, volume, energy, etc.

Changes of Matter

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

Chemical Reactions

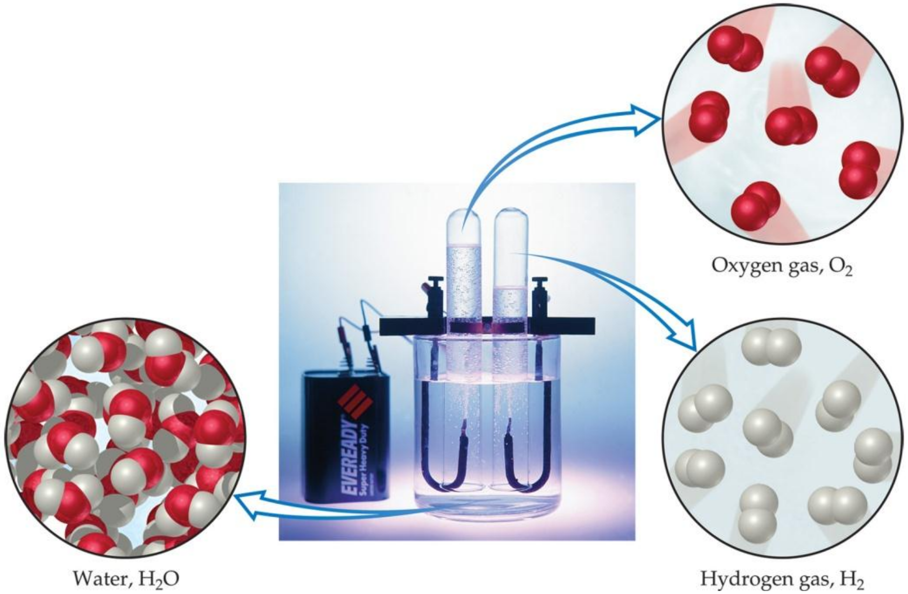


In the course of a chemical reaction, the reacting substances are converted to new substances.

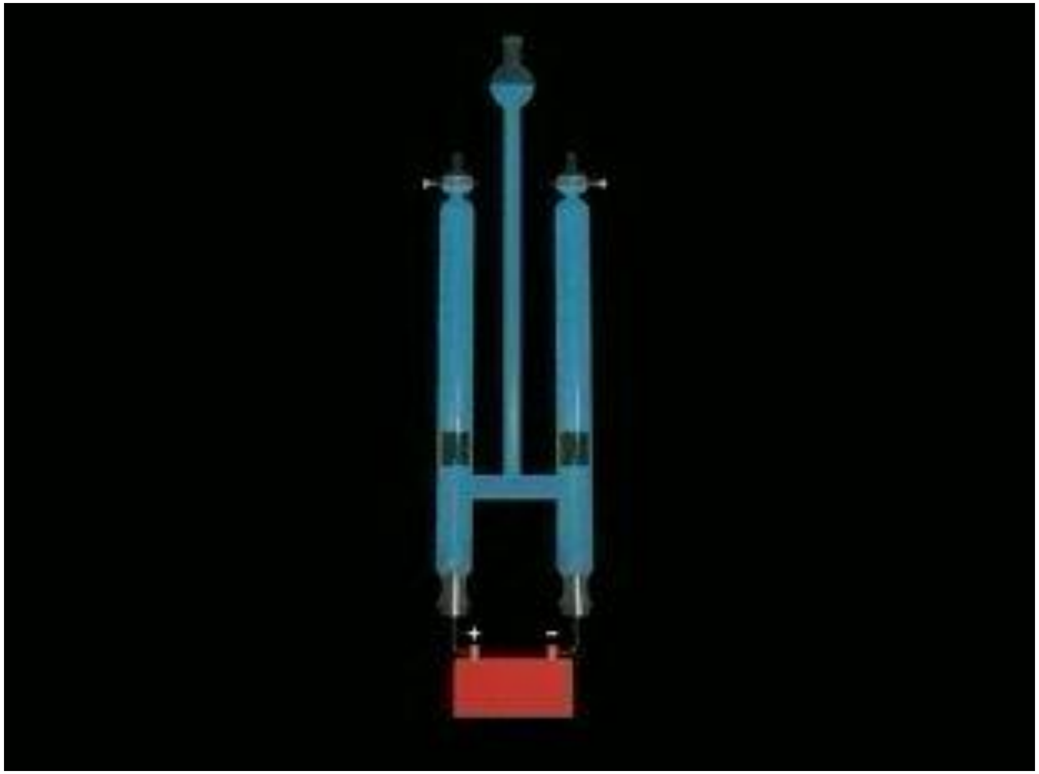
Chemical Reactions

Compounds

Compounds can be broken down into more elemental particles.

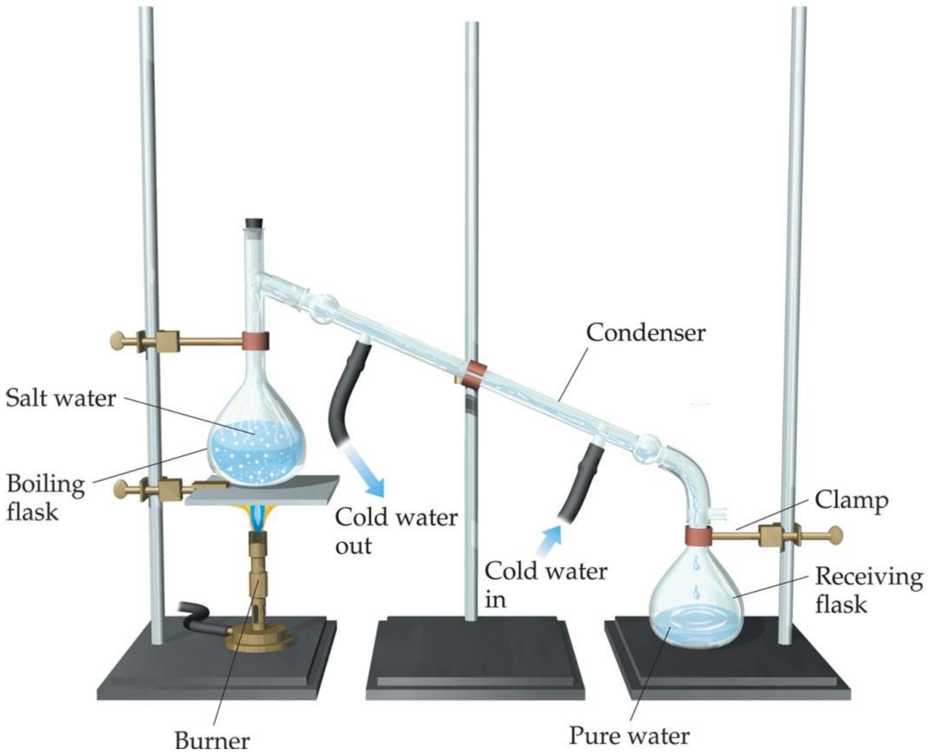


Electrolysis of Water



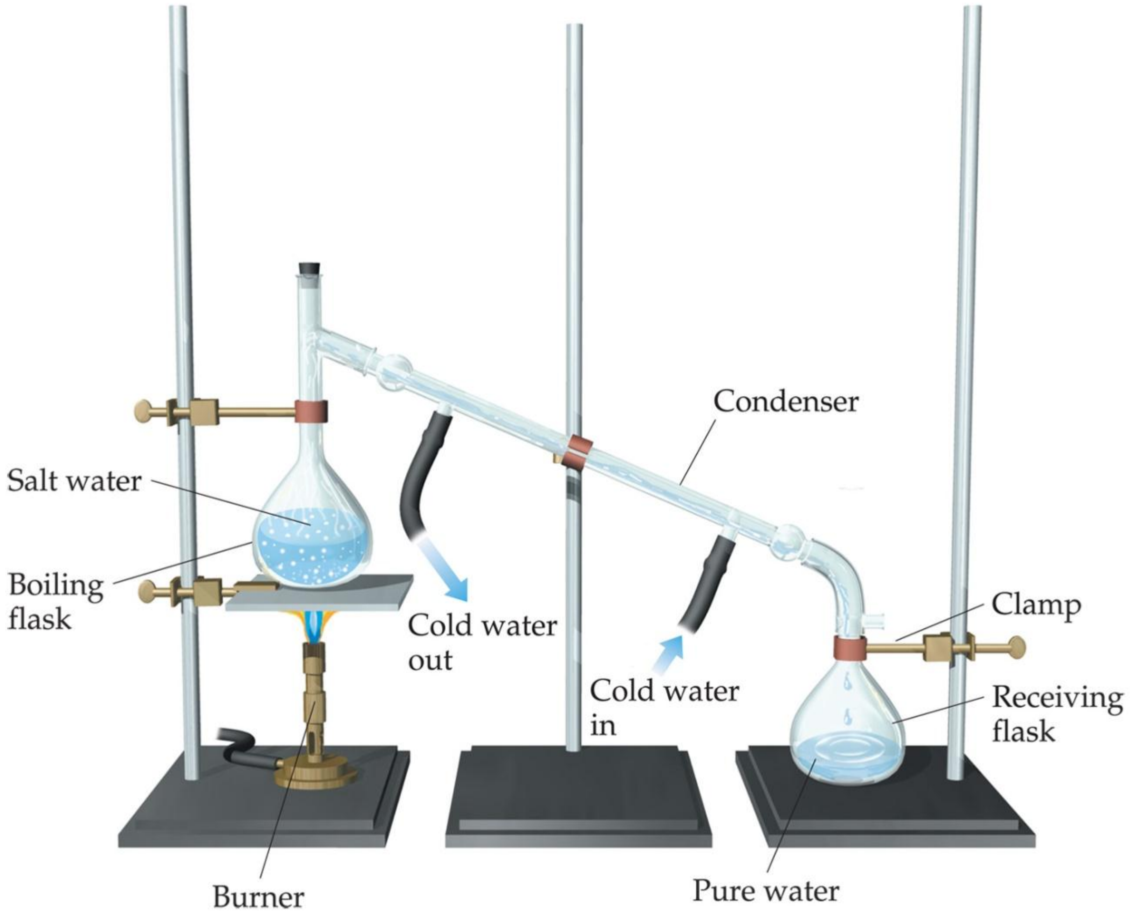
Separation of Mixtures

Distillation:



Separates homogeneous mixture on the basis of differences in boiling point.

Distillation



Matter And Measurement

Filtration:

Separates solid substances from liquids and solutions.

Chromatography:

Separates substances on the basis of differences in solubility in a solvent.

Units of Measurement

Matter
And
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*
- Uses a different base unit 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) $= 1 \times 10^9$ m
Mega	M	10^6	1 megameter (Mm) $= 1 \times 10^6$ m
Kilo	k	10^3	1 kilometer (km) $= 1 \times 10^3$ 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) $= 1 \times 10^{-6}$ m
Nano	n	10^{-9}	1 nanometer (nm) $= 1 \times 10^{-9}$ m
Pico	p	10^{-12}	1 picometer (pm) $= 1 \times 10^{-12}$ m
Femto	f	10^{-15}	1 femtometer (fm) $= 1 \times 10^{-15}$ m

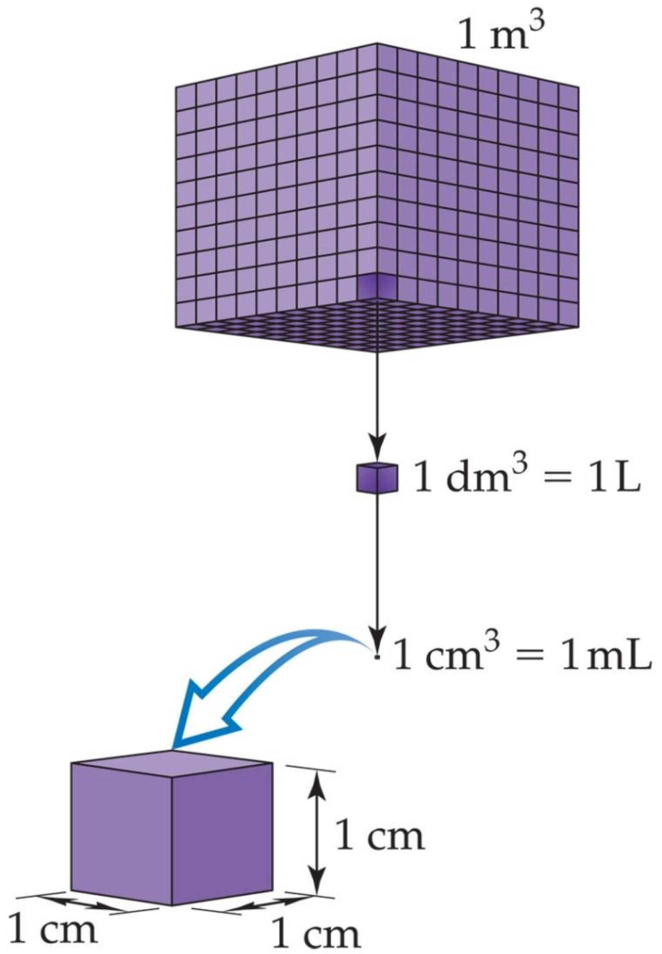
[a]This is the Greek letter mu (pronounced "mew").

- Write down an unusual example of a chemical reaction on a piece of paper and give it to me with your name.

- What is the most abundant element on earth?
- What is the most abundant element in the human body?

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.



1L = 1000 ml

Conversions of units

Length

1 km = 1000 meter

1 meter = 100 cm

1 cm = 10 mm

Mass

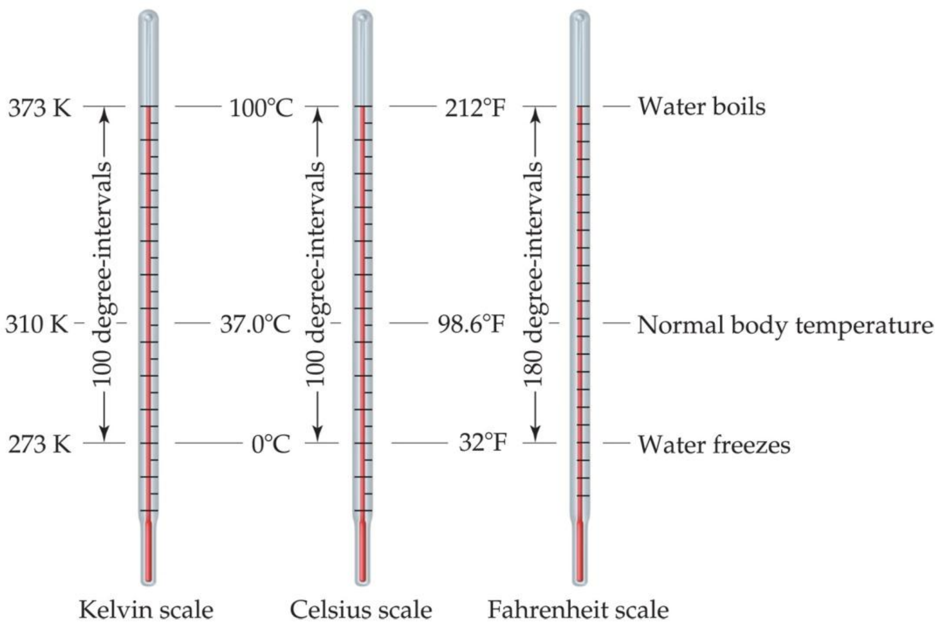
1 kg = 1000 g

1 g = 1000 mg

Volume

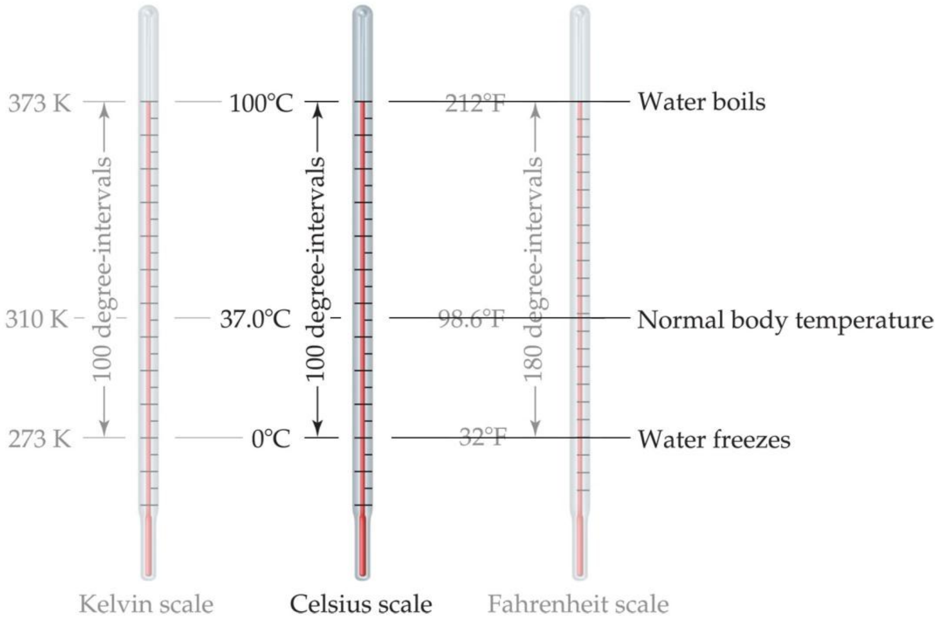
1 L = 1000 ml

Temperature:



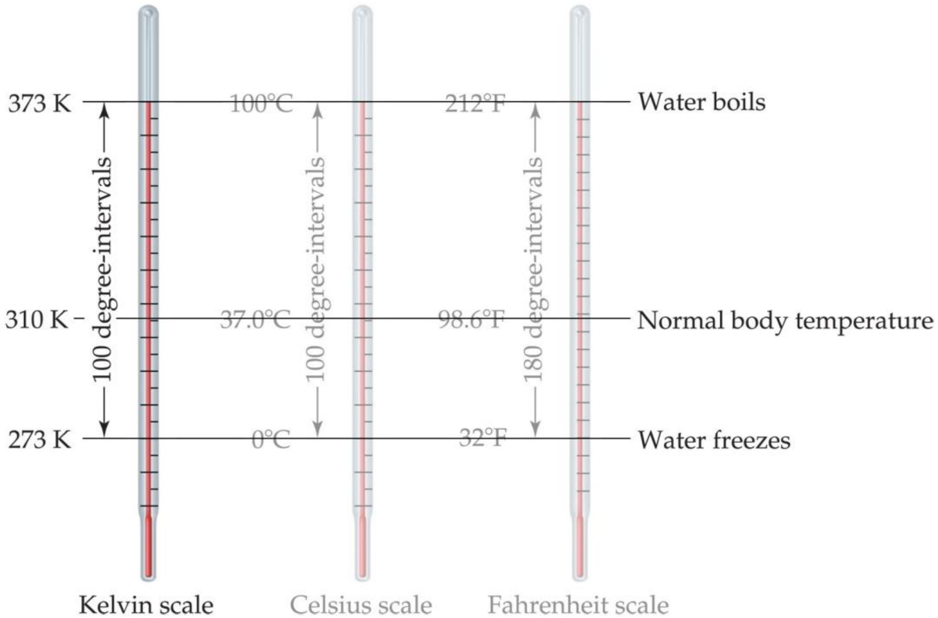
A measure of the average kinetic energy of the particles in a sample.

Temperature



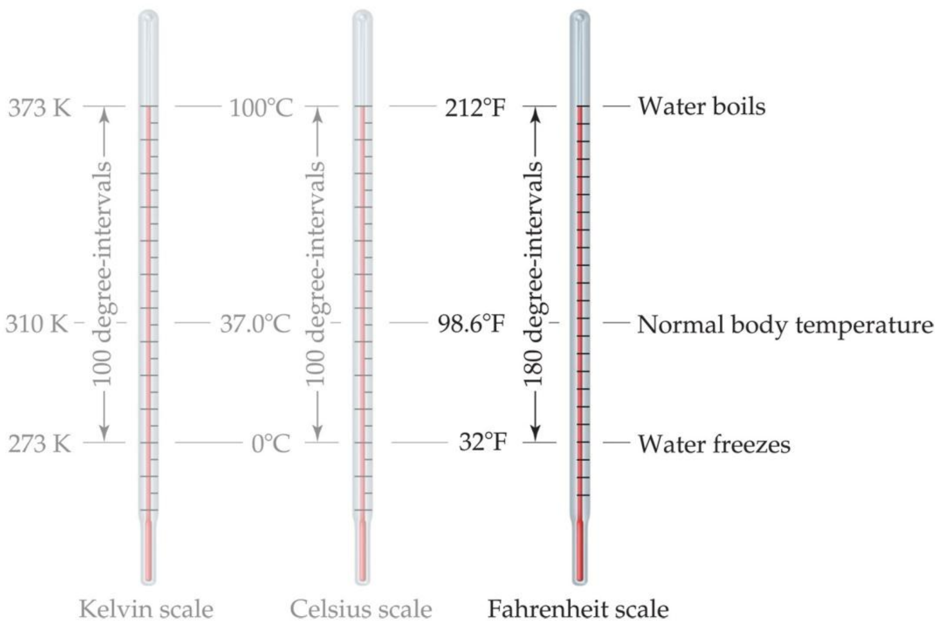
- In scientific measurements, the Celsius and Kelvin scales are most often used.
- The Celsius scale is based on the properties of water.
  - 0°C is the freezing point of water.
  - 100°C is the boiling point of water.

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

Temperature



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

$$°F = 9/5(°C) + 32$$

Matter
And
Measurement

$$°F = 9/5(°C) + 32$$

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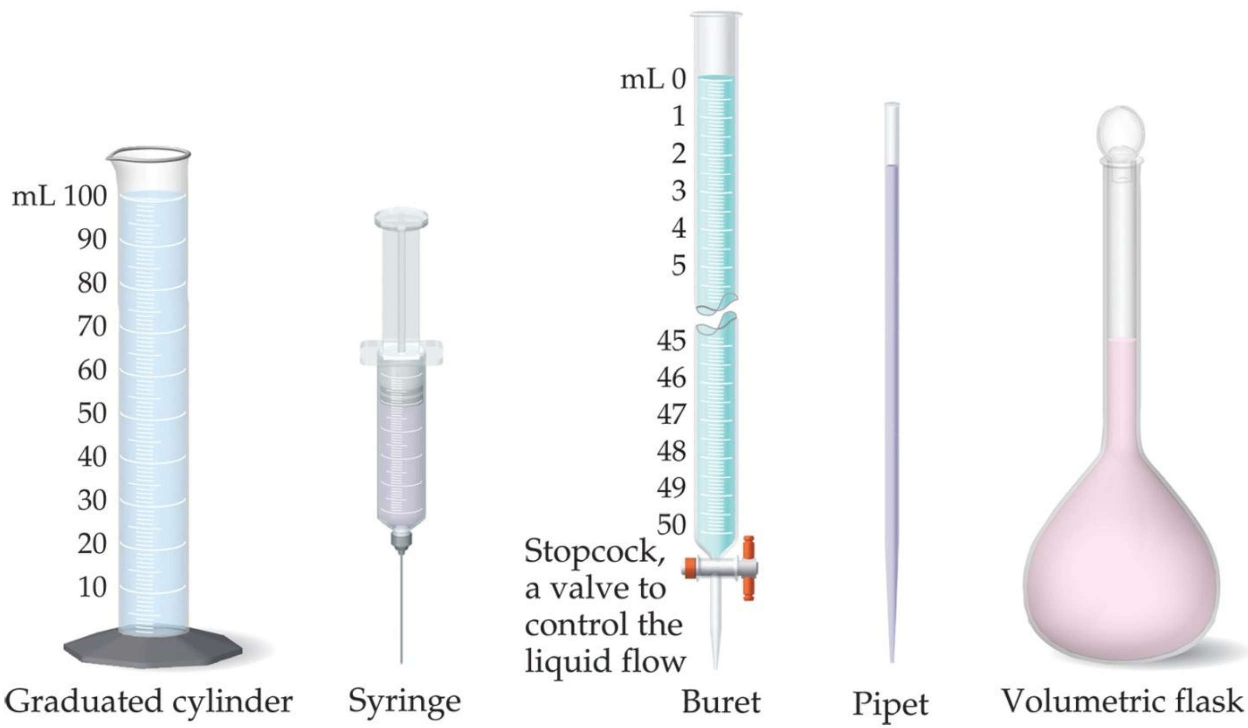
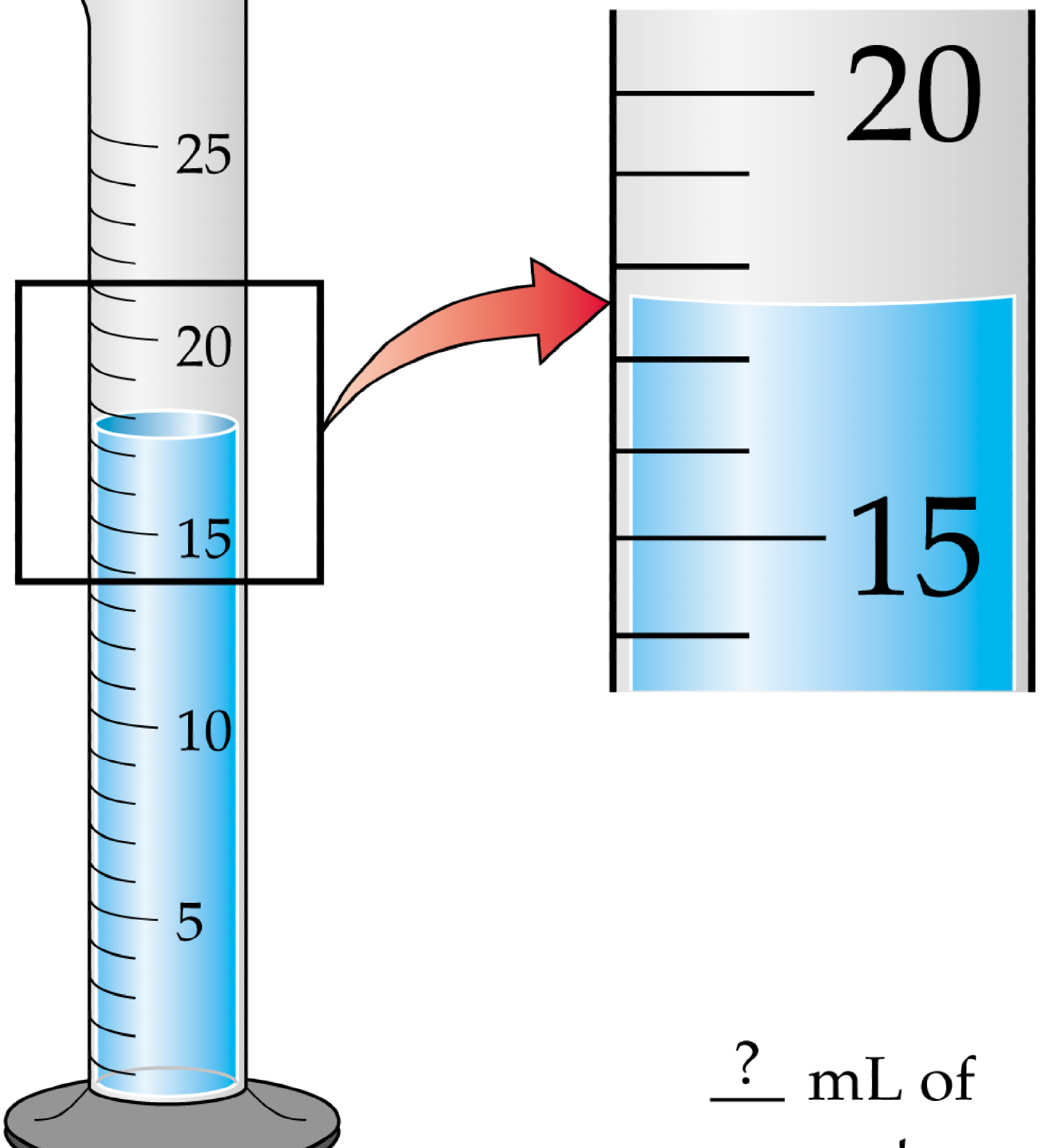
Uncertainty in Measurement

Matter And Measurement

Uncertainty in Measurements

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





? mL of

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.

Exact numbers

- These numbers are the ones whose values are known exactly.

  Counted numbers and

  Conversion factors within a system

  Eg 1km = 1000 m

Relationships between units in *different* unit systems are *usually* not exact:

2.2 lb. = 1.0 kg 2 sig. figs.

2.2046223 lb. = 1.0000000 kg 8 sig. figs.

But the following inter-system conversion factors are now set by definition and are **exact**:

2.54 cm / 1 inch (exactly)

1 calorie / 4.184 Joules (exactly)

Exact Numbers

- The numbers that are obtained by counting and not by measuring are called exact numbers.

    Examples:10 apples, 100 students

- Exact numbers also arise by definition

    Example : 1 inch is defined as exactly

    2.54 cm.

- Exact numbers can be assumed to have an unlimited number of significant figures.
- These do not limit the number of significant figures in a calculation.

Rules for Multiplication and Division

- When multiplying or dividing numbers, the answer reported can not have more significant figures than either of the original numbers.

Three significant figures

Three significant figures

$$\frac{278\ \text{mi}}{11.70\ \text{gal}} = 23.8\ \text{mi/gal}$$

Four significant figures

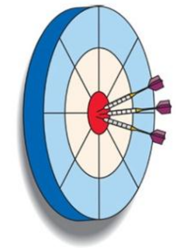
Rules for Addition and Subtraction

When adding or subtracting numbers, the reported answer can not have more digits after the decimal point than any of the added numbers.

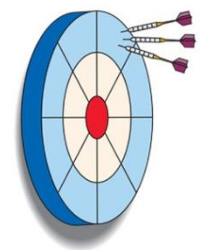
lume of water at start	$3.18?\ \ ??\ \mathrm{L}$	Two digits after decimal p
ume of water addded	$+\ 0.013\ 15\ \mathrm{L}$	Five digits after decimal p
Total volume of water	$3.19?\ \ ??\ \mathrm{L}$	Two digits after decimal p

Accuracy versus Precision

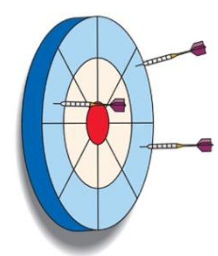
- **Accuracy** refers to the proximity of a measurement to the true value of a quantity.
- **Precision** refers to the proximity of several measurements to each other.



Good accuracy
Good precision



Poor accuracy
Good precision



Poor accuracy
Poor precision

Dimensional Analysis

- This is a very powerful tool for conversion from one unit to another.

- Those of you who were present in today morning’s discussion, please sign the attendance sheet.

Dimensional Analysis

Step 1: write the conversion factors
Step 2: write down two equivalence ratios
Step 3: write the number to be converted with the unit
Step 4: multiply that with the equivalence ratio so that the unit needed in the answer is on the top and the unit that needs to go is on the bottom
Step 5: Calculate the answer

Check to see if your answer makes sense

Examples

- Convert 37 Km/h to m/s

$$37\frac{Km}{h} \text{ x } \frac{1000m}{1Km} \text{ x } \frac{1h}{60min} \text{ x } \frac{1min}{60s}$$

Matter
And
Measurement

- Convert 12 g / L to g/ml

Density:

Physical property of a substance

It gives the mass of the substance per unit volume

Density is temperature dependent

The density of water is 1.0 g/ mL at $25^{o}C$

Any substance that is less dense than water - will float on water

Any substance that is more dense than water - will sink in water

Density:

Physical property of a substance

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