Matter:
Anything that has mass and takes up space
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.

Classification of Matter

- **Matter**
  - **Is it uniform throughout?**
    - **NO**
      - Heterogeneous mixture
    - **YES**
      - **Homogeneous**
        - **Does it have a variable composition?**
          - **NO**
            - Pure substance
          - **YES**
            - Homogeneous mixture (solution)
        - **Can it be separated into simpler substances?**
          - **NO**
            - Element
          - **YES**
            - Compound
Mixtures and Compounds

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.

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

Compounds
Compounds can be broken down into more elemental particles

Separation of Mixtures

Distillation:
Separates homogeneous mixture on the basis of differences in boiling point.
Filtration:
Separates solid substances from liquids and solutions
Chromatography:
Separates substances on the basis of differences in solubility in a solvent.

<table>
<thead>
<tr>
<th>Physical Quantity</th>
<th>Name of Unit</th>
<th>Abbreviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mass</td>
<td>Kilogram</td>
<td>kg</td>
</tr>
<tr>
<td>Length</td>
<td>Meter</td>
<td>m</td>
</tr>
<tr>
<td>Time</td>
<td>Second</td>
<td>s\textsuperscript{a}</td>
</tr>
<tr>
<td>Temperature</td>
<td>Kelvin</td>
<td>K</td>
</tr>
<tr>
<td>Amount of substance</td>
<td>Mole</td>
<td>mol</td>
</tr>
<tr>
<td>Electric current</td>
<td>Ampere</td>
<td>A</td>
</tr>
<tr>
<td>Luminous intensity</td>
<td>Candela</td>
<td>cd</td>
</tr>
</tbody>
</table>

\textsuperscript{a}The abbreviation sec is frequently used.

- \textit{Système International d’Unités}
- Uses a different base unit for each quantity
Prefixes convert the base units into units that are appropriate for the item being measured.

<table>
<thead>
<tr>
<th>Prefix</th>
<th>Abbreviation</th>
<th>Meaning</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Giga</td>
<td>G</td>
<td>$10^9$</td>
<td>1 gigameter (Gm) = $1 \times 10^9$ m</td>
</tr>
<tr>
<td>Mega</td>
<td>M</td>
<td>$10^6$</td>
<td>1 megameter (Mm) = $1 \times 10^6$ m</td>
</tr>
<tr>
<td>Kilo</td>
<td>k</td>
<td>$10^3$</td>
<td>1 kilometer (km) = $1 \times 10^3$ m</td>
</tr>
<tr>
<td>Deci</td>
<td>d</td>
<td>$10^{-1}$</td>
<td>1 decimeter (dm) = 0.1 m</td>
</tr>
<tr>
<td>Centi</td>
<td>c</td>
<td>$10^{-2}$</td>
<td>1 centimeter (cm) = 0.01 m</td>
</tr>
<tr>
<td>Milli</td>
<td>m</td>
<td>$10^{-3}$</td>
<td>1 millimeter (mm) = 0.001 m</td>
</tr>
<tr>
<td>Micro</td>
<td>$\mu^a$</td>
<td>$10^{-6}$</td>
<td>1 micrometer ($\mu$m) = $1 \times 10^{-6}$ m</td>
</tr>
<tr>
<td>Nano</td>
<td>n</td>
<td>$10^{-9}$</td>
<td>1 nanometer (nm) = $1 \times 10^{-9}$ m</td>
</tr>
<tr>
<td>Pico</td>
<td>p</td>
<td>$10^{-12}$</td>
<td>1 picometer (pm) = $1 \times 10^{-12}$ m</td>
</tr>
<tr>
<td>Femto</td>
<td>f</td>
<td>$10^{-15}$</td>
<td>1 femtometer (fm) = $1 \times 10^{-15}$ m</td>
</tr>
</tbody>
</table>

*aThis is the Greek letter mu (pronounced “mew”).

- 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.

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

Temperature:
A measure of the average kinetic energy of the particles in a sample

- In scientific measurements, the Celsius and Kelvin scales are most often used.

- The Celsius scale is based on the properties of water.
  - $0^\circ$C is the freezing point of water.
  - $100^\circ$C is the boiling point of water.

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

- The Fahrenheit scale is not used in scientific measurements.
- $^\circ F = 9/5(^\circ C) + 32$
- $^\circ C = 5/9(^\circ F - 32)$
• Physical property of a substance
  • Density = mass/ volume

Uncertainty in Measurement

• 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.

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

• 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 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