1.1: The Study of Chemistry

An understanding of chemistry is essential for understanding much of the natural world and is central to many other disciplines. Chemistry is the study of matter and the changes material substances undergo. It is essential for understanding much of the natural world and central to many other scientific disciplines, including astronomy, geology, paleontology, biology, and medicine.

The Molecular Perspective of Chemistry

- **Matter** – physical material of the universe, has mass and takes up space
- **Atoms** – the building blocks of matter
- **Molecules** – groups of combined atoms

Why Study Chemistry?

- important in understanding our world
- chemistry is the central science
- many various subjects have some kind of relation to chemistry

1.2: Classification of Matter

Matter can be classified according to physical and chemical properties. Matter is anything that occupies space and has mass. The three states of matter are solid, liquid, and gas. A physical change involves the conversion of a substance from one state of matter to another, without changing its chemical composition. Most matter consists of mixtures of pure substances, which can be homogeneous (uniform in composition) or heterogeneous (different regions possess different compositions & properties).

States of Matter

- states of matter: liquid, solid, and gas

Pure Substances and Mixtures

- **pure substance** – matter that has a fixed composition and distinct properties
- substances can be classified as **elements** or **compounds**
- **elements** – composed of only one atom
- **compounds** – two or more elements
- **mixtures** – combination of two or more substances
- **heterogeneous** – mixtures that are not uniform throughout
- **homogeneous** – mixtures that are uniform throughout; also called solutions

Separation of Mixtures
components in a mixture retain their own properties
mixtures can be separated by using the different properties of each substance
types of separation: filtration, distillation, chromatography

**Elements**

- over 90% of earth’s crust consists of oxygen, silicon, aluminum, iron, and calcium
- human body consists of 90% of oxygen, carbon, and hydrogen

**Compounds**

- law of constant composition (law of definite proportions) – elemental composition of a pure compound is always the same

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### 1.3: Properties of Matter

All matter has physical and chemical properties. Physical properties are characteristics that scientists can measure without changing the composition of the sample under study, such as mass, color, and volume (the amount of space occupied by a sample). Chemical properties describe the characteristic ability of a substance to react to form new substances; they include its flammability and susceptibility to corrosion.

- **physical properties** – properties measured by not changing the identity and composition of the substance
- **chemical properties** – the way a substance may change or react to form other substances
- **intensive properties** – identify substances
- **extensive properties** – amount of substance

### Physical and Chemical Changes

- physical change results in a change in appearance but not composition
- changes of state are physical changes
- chemical changes (chemical reactions) results in a chemically different substance

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### 1.4: Units of Measurement

The natural sciences begin with observation, and this usually involves numerical measurements of quantities such as length, volume, density, and temperature. Most of these quantities have units of some kind associated with them, and these units must be retained when you use them in calculations. Measuring units can be defined in terms of a very small number of fundamental ones that, through “dimensional analysis”, provide insight into their derivation and meaning.

**SI Units**

- seven base units
<table>
<thead>
<tr>
<th>Prefix</th>
<th>Abbreviation</th>
<th>Meaning</th>
</tr>
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<tbody>
<tr>
<td>Mega-</td>
<td>M</td>
<td>$10^6$</td>
</tr>
<tr>
<td>Kilo-</td>
<td>K</td>
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**Length and Mass**

- SI base unit for length is the meter (m)
- Mass is a measure of the amount of material in an object

**Temperature**

- Celsius and Kelvin scales are used commonly in science
- Both have equal sized units
- $K = °C + 273.15$
- $°C = \frac{5}{9}(°F - 32)$
- $°F = \frac{9}{5}(°C) + 32$

**Derived SI Units**

**Volume**

- SI unit is cubic meter
- Equipment to measure volume accurately: syringes, burets, and pipets

**Density**

- density = mass/volume
1.5: Uncertainty in Measurement

Measurements may be accurate, meaning that the measured value is the same as the true value; they may be precise, meaning that multiple measurements give nearly identical values (i.e., reproducible results); they may be both accurate and precise; or they may be neither accurate nor precise. The goal of scientists is to obtain measured values that are both accurate and precise.

1.5.1 Precision and Accuracy

- **precision** – the closeness of individual measurements to one another
- **accuracy** – the correctness of individual measurements

**Significant Figures**

- Nonzero digits are always significant
- Zeros between nonzero digits are always significant
- Zeros at the beginning of a number are never significant
- Zeros that fall both at the end of a number and after the decimal point are always significant
- When a number ends in zeros but contains no decimal point, the zeros may or may not be significant
- Scientific notation can be used to get the correct significant numbers

**Significant Figures in Calculations**

- Addition/Subtraction: the number of *decimal places* is determined by the number that has the fewest *decimal places* in the calculation
- Multiplication/Division: the number of *significant figures* is determined by the number that has the fewest *significant figures* in the calculation

1.6: Dimensional Analysis

Dimensional analysis is used in numerical calculations, and in converting units. It can help us identify whether an equation is set up correctly (i.e. the resulting units should be as expected). Units are treated similarly to the associated numerical values, i.e., if a variable in an equation is supposed to be squared, then the associated dimensions are squared, etc.

- aid in problem solving
- conversion factor – fraction where the numerator and denominator are the same quantity