Chem 101: General Chemistry
Lecture 1 - Matter, Measurements, and Calculations

I. Introduction

A. Matter is the substance of everything

B. Chemistry is the study of matter
   1. Understanding chemistry is necessary for individuals who are studying a wide variety of areas
      a. Health Sciences
      b. Biology
      c. Geology
      d. Astronomy
      e. Law enforcement

C. This chapter
   1. Presents some fundamental ideas about matter
   2. Quantitative measurements
   3. Scientific measurement system

II. What is Matter?

A. Definitions
   1. What is *chemistry*?
      a. The study of matter
   2. What is *matter*?
      a. Occupies volume and has mass
   3. What is *mass*?
      a. Is the measure of the amount of something
      b. In physics it is related to forces and inertia (resistances to forces)
         i. Would you rather kick a balloon or a bowling ball?
         ii. The gravitational pull on an object is proportional to its mass.
   4. What is *weight*.
      a. It is the amount of gravitational pull on an object.
         i. A rock weighing 16 pounds on earth would way 2.7 pounds on the moon. (1/6).
         ii. The rock has the same mass on both the earth and the moon.
      b. We will often use the term *weight* when we mean *mass*
      c. Scales are used to measure weight, whereas balances are used to measure mass.

Exercise 1.3: Prove that air is matter.

III. Properties and Changes

A. Properties are those things that allow you to distinguish one object from another
   1. Compare the rock, the water and the air-filled balloon.

B. There are two basic categories of properties
   1. Physical Properties

a. Those observed or measured without changing or trying to change the composition of the matter.

2. Chemical Properties
   a. Burn the candle

C. Physical *versus* Chemical change
1. Physical change is where the physical properties of a substance changes without a change in its chemical composition.
   a. For example
      i. Ice melting
      ii. Water evaporating

IV. A Model of Matter

A. Scientific Models
1. Are created to help us "visualize" the natural world around us.
2. Models are developed to explain observed behaviors.
3. The can be used to predict new behaviors.

B. Observed behaviors of gases include:
1. Volume at constant temperature decreases with increasing pressure.
2. Volume maintained at constant pressure increases with increasing temperature.
3. Gases have mass.
4. Gases mix readily with one another.

C. From these observations a simple model of matter was created which works not only with gases, but also with liquids and solids:
1. Matter is made up of tiny particles called **molecules**.
2. Molecules are the smallest division of matter that displays the chemical and physical properties of a pure substance.
   a. Any further subdivision requires a chemical changes, which changes the composition and hence the chemical and physical properties of the matter.

D. Molecules are made of **atoms**.
1. Atoms are the smallest division of an element.
2. Different atoms are combined in different proportions to make different molecules
   a. Each type of molecule contains a fixed composition of atoms in a fixed proportion.
      i. For example:
         1. All water molecules (H_2O) contain 2 hydrogen atoms plus 1 oxygen atom.
         2. All carbon dioxide molecules (CO_2) contain 1 carbon atom plus 2 oxygen atoms.
         3. All oxygen molecules (O_2) contain 2 oxygen atoms.

V. Classification of Matter

A. All matter is either a **pure substance** or a **mixture of pure substances**.
1. Pure substances have a fixed composition and a defined set of chemical and physical properties
   a. Example, water is a pure substance

i. It freezes at 0° C
ii. It boils as 100°C
iii. Its composition is always two parts hydrogen to two parts oxygen.

b. Example, table sugar (sucrose) is a pure substances
i. It also has a defined set of physical properties and its composition is 12 parts carbon, to 22 parts hydrogen to 11 parts oxygen.

c. The physical and chemical properties of a pures substance can be quite different than the chemical and physical properties of the elements that make up its molecules
i. For example
1. Water is a clear, colorless liquid that is not flammable.
2. Hydrogen is a clear, colorless gas that is highly flammable.
3. Oxygen is a clear, colorless gas that is not flammable but reacts readily with many other substances.

2. Mixtures are mixtures of pure substances
a. Example, sugar water is a mixture
i. Its composition varies depending on how much sugar is dissolved in the water.
ii. Its physical properties varies with composition,
1. When making candy, the boiling point of sugar water increases as the water is boiled off.
a. Correspondingly, its physical properties change. “Soft ball”, “Hard ball”, *etc*.

b. The pure substances in a mixture can be separated by physical means.
i. For example, salt water is a mixture
1. The components of this mixture can be separated by boiling off the water, leaving the salt behind

c. The physical and chemical properties of a mixture resemble a mixing of the physical and chemical properties of the pure substances of which it is made.

d. Mixtures can be **heterogenous** or **homogeneous**.
i. Homogeneous mixtures are mixed at the molecular level.
1. The look the same every where.
2. For example: sugar water.
3. The word **solution** is often used to refer to homogeneous mixtures.
ii. Heterogeneous mixtures are lumpier.
1. For example, a mixture of sugar and sand.
a. Close examination reveals the individual grains of sugar and sand.

Figures 1.5, 1.9 and 1.10: Elements, pure substances, compounds, mixtures, *etc*.

3. Elements
a. Pure substances composed of *homoatomic* molecules are called **elements**.
b. There are a little over 100 elements, which are displayed on the periodic table of the elements.

c. The smallest division of some elements is an atom instead of molecules.
   i. For example, the elements in the last column of the periodic table, which are called Noble or inert gases.

4. Compounds
   a. Pure substances composed of *heteroatomic* molecules are called **compounds**.
      i. There a millions of different kinds of compounds.
   b. Elements cannot be chemically divided into simpler pure substances, but compounds can.
      i. For example, the electrolysis (a chemical change) of water (a compound) produces hydrogen (an element) and oxygen (an element).
         1. Neither hydrogen, nor oxygen, can be reduced any further.

VI. Measurement Units

A. Units give numbers meaning
   1. When doing measurements in the lab it is important to always include the units.
   2. When working problems it is also important to include the units
      a. Analyzing the units can help you determine if you have worked the problem correctly.

B. For the most part we will be using the SI (Système International d'Unités)
   1. This is based on the metric system
   2. The basic units in the SI system are
      a. Mass - kilograms
      b. Length - meters
      c. Time - seconds

VII. The Metric System

A. The metric system is a decimal system

B. Most units are derived
   1. Area - meters x meters (m^2)
   2. Volume - meters x meters x meters (m^3)
   3. Energy - kilograms x meter x meter / (second x second) ($kg \bullet m^2/s^2$)
   4. Some derived units have their own name
      a. 1 *Joule* = 1 $kg \bullet m^2/s^2$

C. Prefixes are used to scale the units

Table 1.2 - Common prefixes of the metric system

D. Commonly used metric units and conversions

Table 1.3 - Commonly used metirc units

Exercises 1.29

VIII. Large and Small Numbers

A. Can use metric prefixes to move decimal place around

B. Also use scientific notation
   1. Review entering scientific notation in calculator
   2. Adding exponents in multiplication
   3. Subtracting exponents in division

IX. Significant Figures

A. Report all digits you a confident in plus the first digit that you are uncertain about.

B. Addition and subtraction

C. Multiplication and Division

D. Exact numbers
   1. 1m = 100 cm

X. Using Units in Calculations

A. Write down what you know and what you want to find out

B. Include units in calculations

C. Do calculations with the units first to see if you answer will have the correct units.

D. Plug numbers into calculator

XI. Percent Calculations

A. Part/Whole X 100%

XII. Density

A. Density = mass/volume