Chapter 1.1 – Chemistry is a Physical Science

Chemistry is one of the many branches of science. It is the study of matter and the changes it undergoes. Other fields include: Biology and Earth Science.

Branches in the field of Chemistry
- Organic
- Inorganic
- Physical
- Analytical
- Biochemistry
- Theoretical

See pg 4 in your textbook.

A chemical is any substance that has a definite composition.

Types of Scientific Investigations
- Pure (Basic) – for the sake of knowledge.
- Applied – used to solve a specific problem.

Technology – the application of science in our everyday lives.

Chapter 1.2 – Matter and its Properties

Everything is made up of matter, from things you can touch and feel to those you cannot. By definition, matter is anything that has mass and takes up space. Mass is a measurement of the amount of matter in an object. So your textbook is matter and so is the air you breathe. Things though that are not matter include heat, light, sound (waves) and electricity.

Mass and Weight
Mass and weight are often terms that are easily confused. While mass is the amount of matter in an object, weight takes into effect force of gravity on matter. An object, such as a marble statue, will have a fixed mass but if we were to transport it to another planet, its weight would change due to the different gravitational force on another planet. Mass is a way to measure matter independent of gravitational force.

The building blocks of matter are atoms. An atom is the smallest unit of an element that maintains the chemical identity of that element. An element is a pure substance that cannot be broken down into simpler, stable substances and is made of only one type of atom. A compound is a substance that can be broken down into simpler substances. Each compound is made from the atoms of elements that are chemically bonded together. A molecule is the smallest unit of an element or compound that retains all the properties of that element or compound.

Physical Properties and Physical Changes
Physical properties can be observed or measured without changing the composition of matter. Physical properties are used to observe and describe matter. The same element or compound is present before and after the change. The same molecule is present throughout the changes. Physical changes are related to physical properties since some measurements require that changes be made.

The three states of matter are: solid, liquid, and gas. The melting point and boiling point are related to changes of the state of matter. All matter may exist in any of three physical states of matter.

Physical properties of matter can be intensive or extensive. An intensive property does not depend on the amount of matter present while extensive properties do.

Examples of extensive properties include:
- Mass - A measurement of the amount of matter in an object (grams).
- Weight - A measurement of the gravitational force of attraction of the earth acting on an object.
- Volume - A measurement of the amount of space a substance occupies.
Examples of intensive properties include:

- Color
- Odor
- Texture
- Solubility
- Polarity
- Luster - How shiny a substance is.
- Malleability - The ability of a substance to be beaten into thin sheets.
- Ductility - The ability of a substance to be drawn into thin wires.
- Conductivity - The ability of a substance to allow the flow of energy or electricity.
- Hardness - How easily a substance can be scratched.
- Melting/Freezing Point - The temperature at which the solid and liquid phases of a substance are in equilibrium at atmospheric pressure.
- Boiling Point - The temperature at which the vapor pressure of a liquid is equal to the pressure on the liquid (generally atmospheric pressure).
- Density - The mass of a substance divided by its volume

Physical Changes
Changes in matter that do not alter the identity of the matter itself.
For example:

- Size
- Shape
- Changes of State - solid liquid gas
- Dilutions

Chemical Properties and Chemical Changes

Chemical properties of matter describe its "potential" to undergo some chemical change or reaction by virtue of its composition. What elements, electrons, and bonding are present to give the potential for chemical change?

It is quite difficult to define a chemical property without using the word "change". Eventually you should be able to look at the formula of a compound and state some chemical property. At this time this is very difficult to do and you are not expected to be able to do it.

For example hydrogen has the potential to ignite and explode given the right conditions. This is a chemical property.

Metals in general have they chemical property of reacting with an acid. Zinc reacts with hydrochloric acid to produce hydrogen gas. This is a chemical property.

Chemical change results in one or more substances of entirely different composition from the original substances. The elements and/or compounds at the start of the reaction are rearranged into new product compounds or elements.

A CHEMICAL CHANGE alters the composition of the original matter. Different elements or compounds are present at the end of the chemical change. The atoms in compounds are rearranged to make new and different compounds.

Magnesium reacts with oxygen from the air producing an extremely bright flame. This is a chemical change since magnesium oxide has completely different properties than magnesium metal shown on the left.

The atoms are rearranged - diatomic oxygen molecules are split apart so that one oxygen atom combines with one magnesium atom.
Iron rusting: \[4 \text{Fe(s)} + 3 \text{O}_2(\text{g}) \rightarrow 2 \text{Fe}_2\text{O}_3 + 3 \text{H}_2\text{O}\]

Wood burning

Copper turning to brass

Common Errors
- Ice melting, water freezing, water evaporating, and steam condensing are all examples of a state change.
- These are physical changes, not chemical.
- Diluting a solution is a physical change, even if the color becomes fainter.


Classification of Matter (see Figure 8 pg 11)

Matter

Mixtures

Pure Substances

Heterogeneous Homogeneous Compounds Elements

**Mixture**
Two or more substances, combined in varying proportions - each retaining its own specific properties. The components of a mixture can be separated by physical means, i.e. without the making and breaking of chemical bonds. Examples: Air, table salt thoroughly dissolved in water, milk, wood, and concrete.

**Heterogeneous Mixture**
Mixture in which the properties and composition are not uniform throughout the sample. Examples: Milk, wood, and concrete.

**Homogeneous Mixture**
Mixture in which the properties and composition are uniform throughout the sample. Such mixtures are termed solutions. Examples: Air and table salt thoroughly dissolved in water.

**Pure Substance**
A substance with constant, fixed composition. Can be classified an either an element or as a compound. Examples: Table salt (sodium chloride, NaCl), sugar (sucrose, C\text{12}H\text{22}O\text{11}), water (H\text{2}O), iron (Fe), copper (Cu), and oxygen (O\text{2}).

Chapter 1.3 – Elements and an Intro to the Periodic Table
Vertical columns are called groups (18). Elements within a group have similar properties.

Horizontal rows called periods (7). Elements within a period have different properties from one another.

There are three main types of elements: metals, nonmetals and metalloids (semimetals).

Properties of metals:

Metals are shiny solids at room temperature (except mercury), with characteristic high melting points and densities. Many of the properties of metals, including large atomic radius, low ionization energy, and low electronegativity, are due to the fact that the electrons in the valence shell of a metal atoms can be removed easily. One characteristic of metals is their ability to be deformed without breaking. Malleability is the ability of a metal to be hammered into shapes. Ductility is the ability of a metal to be drawn into wire. Because the valence electrons can move freely, metals are good heat conductors and electrical conductors.

Summary of Common Properties of Metals
- Shiny 'metallic' appearance
- Solids at room temperature (except mercury)
- High melting points
- High densities
- Large atomic radii
- Low ionization energies
- Low electronegativities
- Malleable
- Ductile
- Good Thermal conductors
- Good Electrical conductors

Properties of nonmetals:

Nonmetals have high ionization energies and electronegativities. They are generally poor conductors of heat and electricity. Solid nonmetals are generally brittle, with little or no metallic luster. Most nonmetals have the ability to gain electrons easily. Nonmetals display a wide range of chemical properties and reactivities.

Summary of Common Properties
- High ionization energies
- High electronegativities
- Poor thermal conductors
- Poor electrical conductors
- Many are gases at room temperature – those that are not are brittle solids
- Little or no metallic luster
- Gain electrons easily

Metalloids have properties of metals and nonmetals. Silicon is used in computer chips because of its unique properties- sometimes it conducts electricity, sometimes it does not.

Properties

The electronegativities and ionization energies of the metalloids are between those of the metals and nonmetals, so the metalloids exhibit characteristics of both classes. Silicon, for example, possesses a metallic luster, yet it is an inefficient conductor and is brittle. The reactivity of the metalloids depends on the element with which they are reacting. For example, boron acts as a nonmetal when reacting with sodium yet as a metal when reacting with fluorine. The boiling points, melting points, and densities of the metalloids vary widely. The intermediate conductivity of metalloids means they tend to make good semiconductors.

Summary of Common Properties of Metalloids
- Solids at room temperature
• Electronegativities between those of metals and nonmetals
• Ionization energies between those of metals and nonmetals
• Possess some characteristics of metals/some of nonmetals
• Reactivity depends on properties of other elements in reaction
• Often make good semiconductors