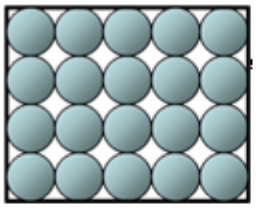
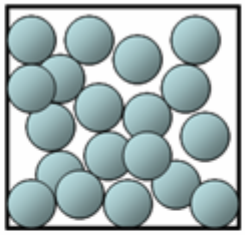
Section 1.1: Introduction

In this course, we will be studying **matter**, "the stuff things are made of". There are many ways to classify matter. For instance, matter can be classified according to the **phase**, that is, the physical state a material is in. Depending on the pressure and the temperature, matter can exist in one of three phases (solid, liquid, or gas). The chemical structure of a material determines the range of temperatures and pressures under which this material is a solid, a liquid or a gas.

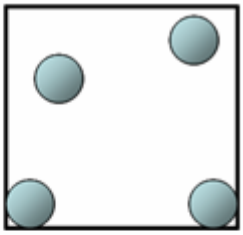
Consider water for example. The principal differences between water in the solid, liquid and gas states are simply: 1) the average distance between the water molecules; small in the solid and the liquid and large in the gas and 2) whether the molecules are organized in an orderly three-dimensional array (solid) or not (liquid and gas).



Solid State
Ordered and dense
Has a definite shape and volume.
Solids are very slightly compressible.



Liquid State
Disordered and usually slightly less dense.
Has a definite volume and takes the shape of the container.
Liquids are slightly compressible.



Gas State
Disordered and much lower density than crystal or liquid.
Does not have definite shape and volume.
Gases are highly compressible.

Another way to classify matter is to consider whether a substance is pure or not. So, matter can be classified as being either a **pure substance** or a **mixture**. A pure substance has unique composition and properties. For example, water is a pure substance (whether from Texas or Idaho, each water molecule always contains 2 atoms of hydrogen for 1 atom of oxygen). Under the same atmospheric pressure and at the same ambient temperature, water always has the same density.

We can go a little further and classify mixtures are either **homogeneous** or **heterogeneous**. In a homogeneous mixture, for example, as a result of mixing a teaspoon of salt in a glass of water, the composition of the various components and their properties are the same throughout. Different aliquots of this salt

solution would have the same density. In contrast, dropping gold coins or a teaspoon of oil in a glass of water will result in the formation of a heterogeneous mixture. Different aliquots will contain different amounts of oil or of gold depending on whether these aliquots are taken from the top or the bottom of the mixture. A homogeneous system exhibits a single phase, while a heterogeneous one exhibits multiple phases (different solids, liquids or mixtures of these).

In the rest of this chapter, we will focus on **pure substances**. There are only two kinds of pure substances: 1) **elements** and 2) **compounds**.

Elements are the simplest form of matter and cannot be broken down using chemical methods into two or more pure substances.

> For example, iron is a pure substance, You can take a piece of iron and break it down into smaller and smaller pieces, but each of these smaller pieces has the same properties as the starting material (hence, it is always the same substance).

Compounds, on the other hand, can be broken down into two or more pure substances.

> For example, H_2O or water can be broken down into H_2 (hydrogen gas) and O_2 (oxygen gas). Similarly, table salt or NaCl can be broken down into Na (sodium metal) and Cl_2 (chlorine gas). Compounds are therefore defined as being made of at least two different elements. A compound is a pure substance with unique composition and properties. Hence, NO_2 and N_2O are different compounds since they have different compositions.

Compounds made with only two elements (such as H_2O, NO_2, N_2O, NaCl) are called **binary compounds**.

The chart showing all known elements and giving some of their properties is the **Periodic Table of the Elements**.