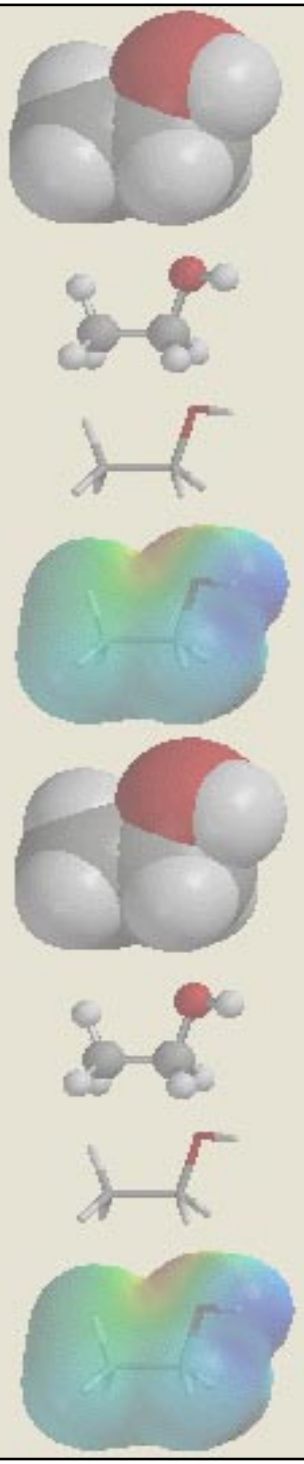
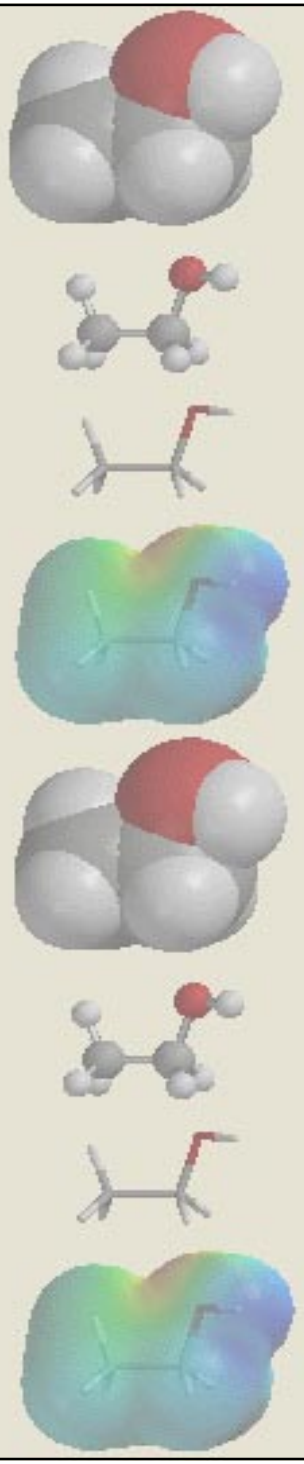


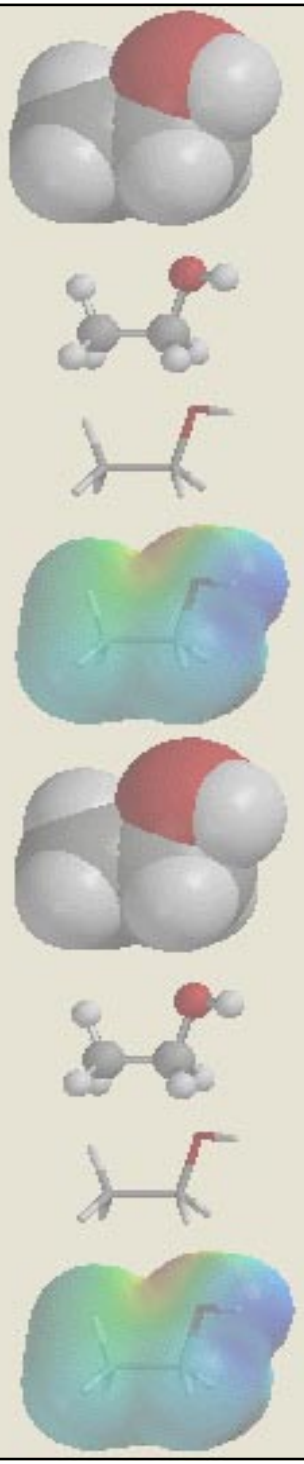
Chem101 - Lecture 1

Matter, Measurements And Calculations



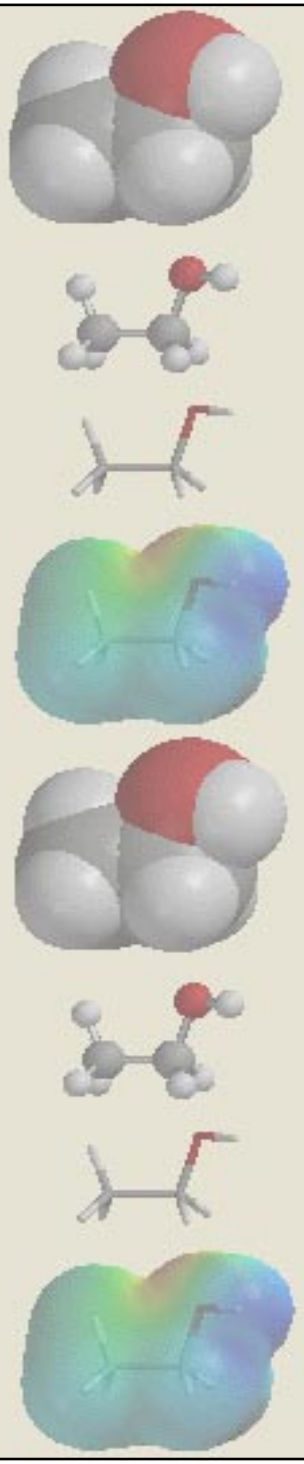
What is Chemistry?

- **Chemistry** is the study of *matter*
- Much of what we interact with in the world around us is made up of matter.



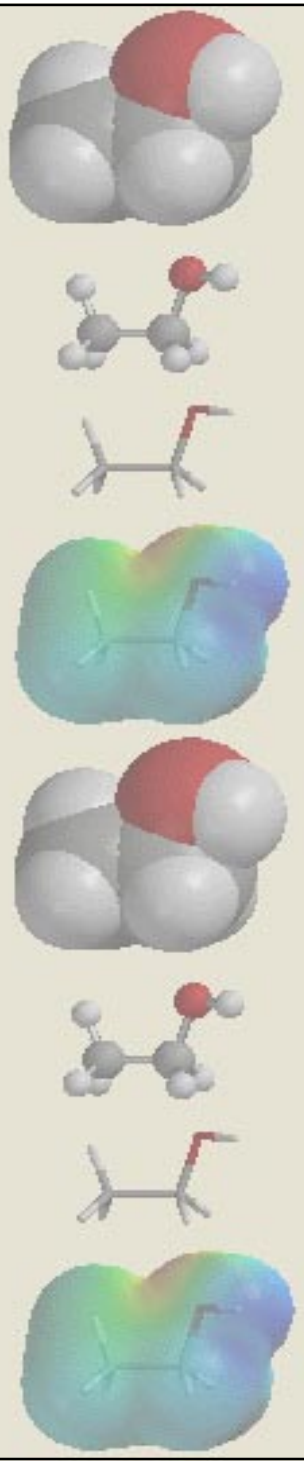
What then is *matter*?

- **Matter** is anything that has *mass* and *occupies space* (has volume)



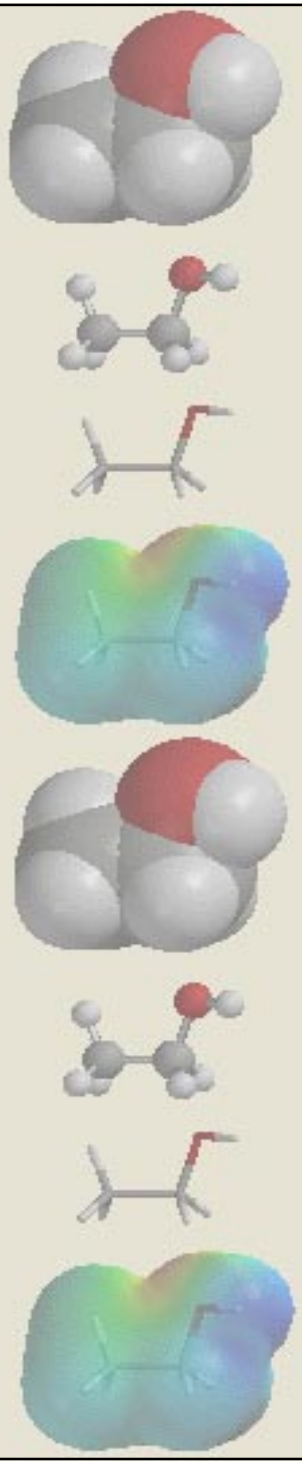
Then what is *mass*?

- **Mass** is a measurement of the amount of matter in a object
  - These definitions may seem cyclical to you.
  - We will see that mass is directly related to the number of atoms that an object contains.



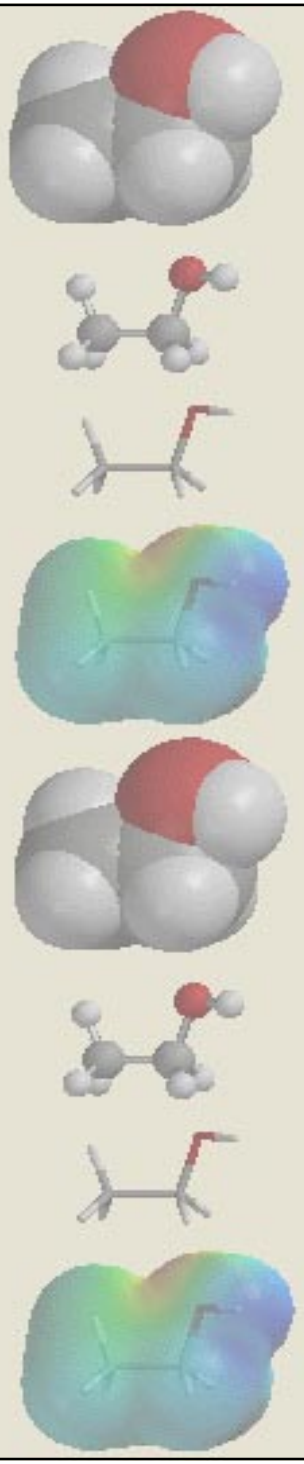
Then what is *mass*?

- In physics we learn that an object's mass is equivalent to its *inertia*.
  - It is a measure of how much an object resists changes in its velocity or direction of movement.



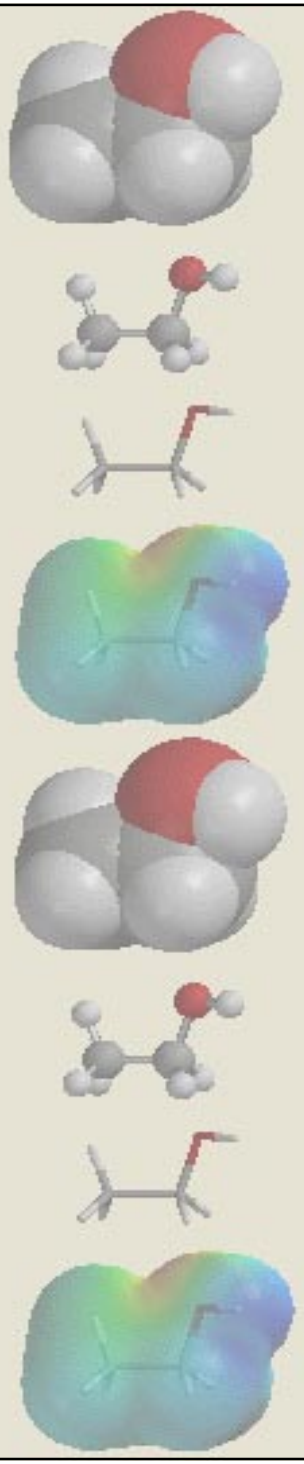
Exercise 1.1

A heavy steel ball is suspended by a thin wire. The ball is hit from the side with a hammer, but hardly moves. Describe what you think would happen if this identical experiment were carried out on the moon.



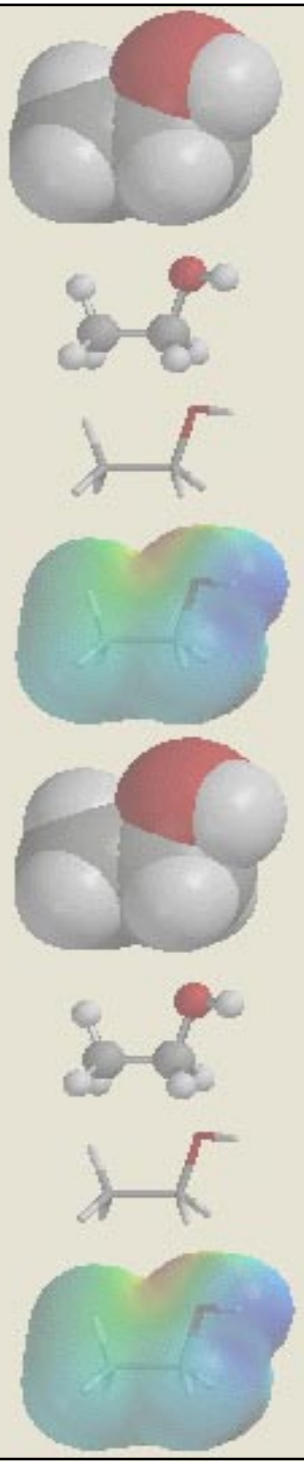
What is *weight*?

- **Weight** is the force that an object exerts on another object due to gravitational attraction.
- Weight is directly proportional to mass
  - This is why the Earth has such a strong attraction for objects.



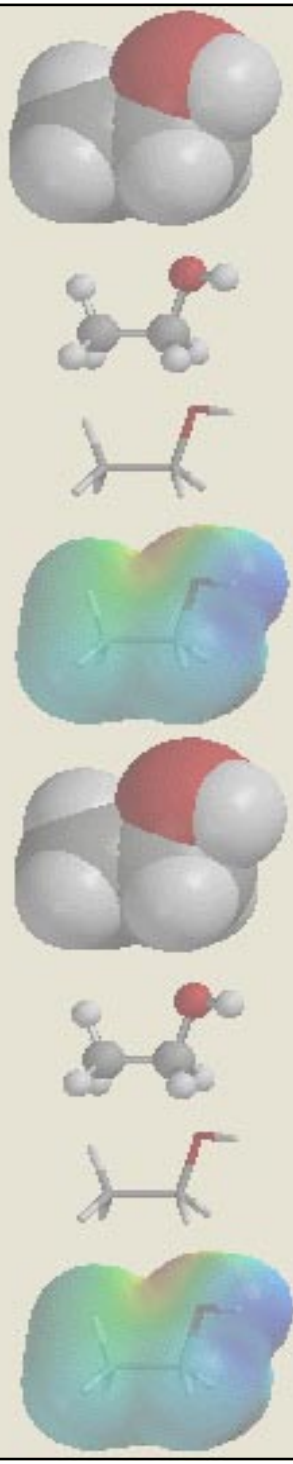
What is *weight*?

- At the surface of the Earth the proportionality constant, relating weight to mass, is essentially the same everywhere.
- This allows us to use the two terms (mass and weight) interchangeably.



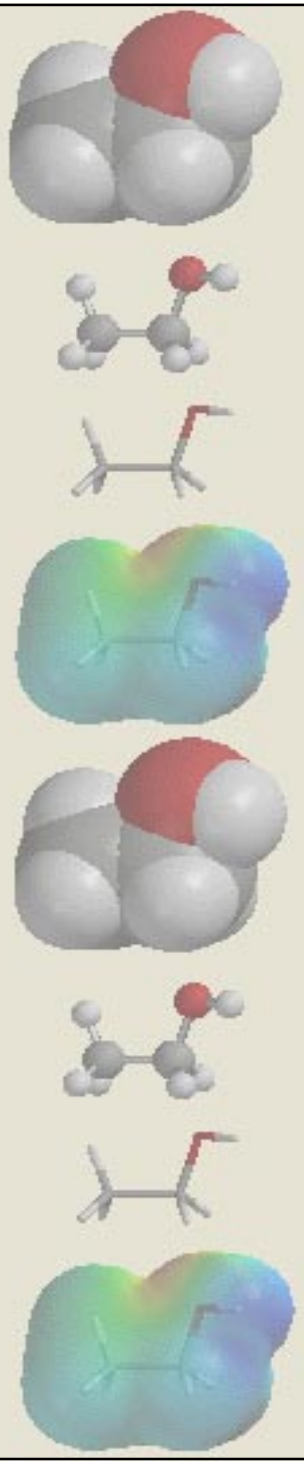
Measuring mass and weight

- In lab you will learn
  - That the mass of an object is determined using a *balance*,
  - While the weight of an object is determined using a *scale*.



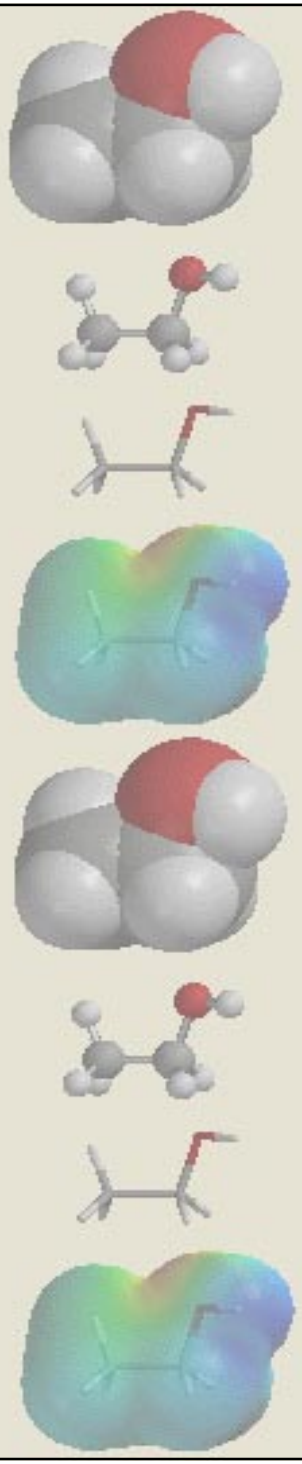
Properties and Changes

- **Properties** are the characteristics of an object that allow us to distinguish it from other objects.
- There are two basic categories of properties:
  - **Physical properties**
  - **Chemical properties**



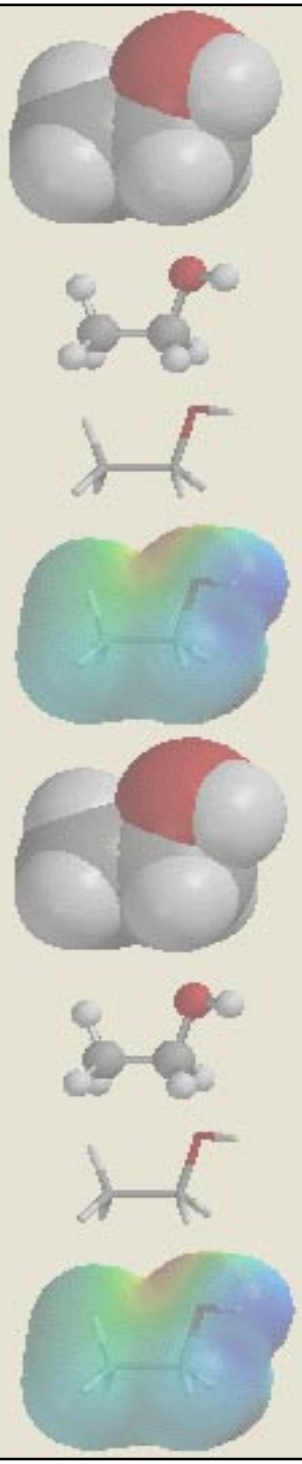
Physical Properties

- **Physical properties** of matter are properties that can be observed or measured without trying to change the composition of the matter being observed.
- For example
  - Color, size, density, melting point, *et al.*



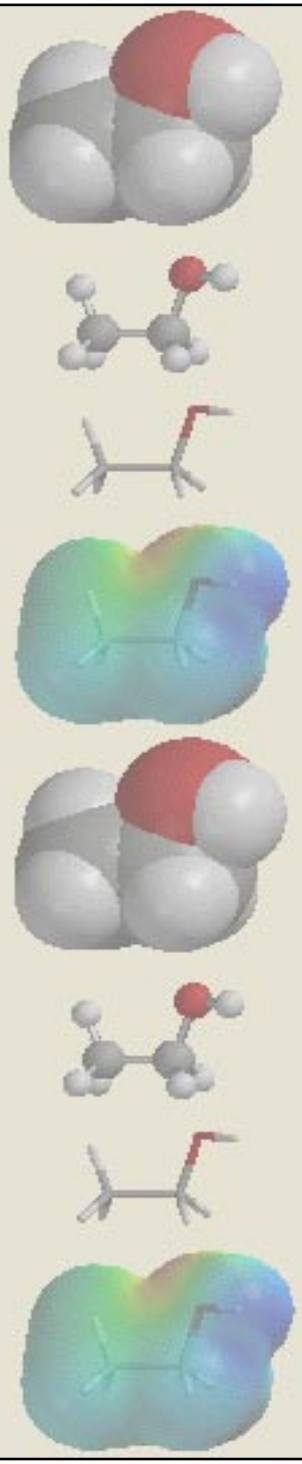
Chemical Properties

- **Chemical properties** of matter are properties that are observed when an attempt is made to change the composition of the matter.
- For example
  - Paper burns easily.
  - Glass does not
- When paper burns, its composition changes.



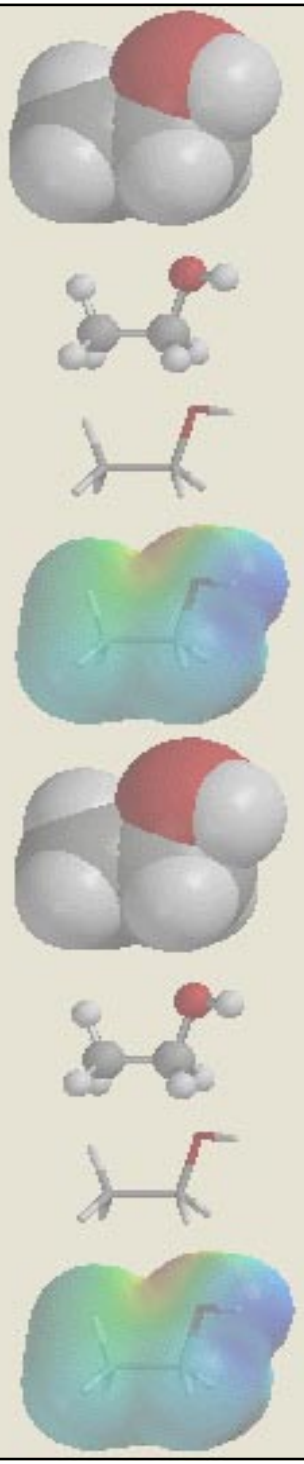
Chemical Change

- Burning a piece of paper is an example of a **chemical change**.
- Chemical change occurs whenever the composition of a substance changes.
- When a chemical change occurs the physical properties of the matter also change.



Physical Change

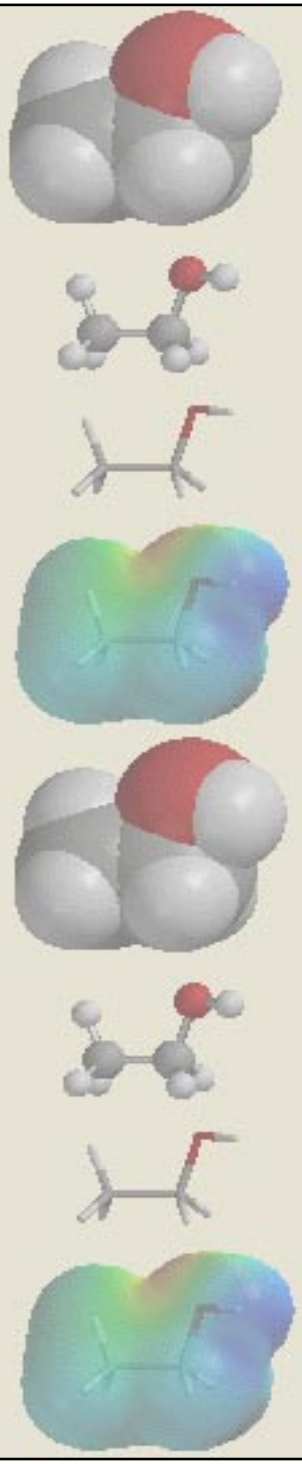
- The physical properties of matter can change, however, *without* a chemical change.
- For example
  - When ice melts to form liquid water
  - When liquid water evaporates to form water vapor
- Such changes are called **physical changes**.



Exercise 1.9

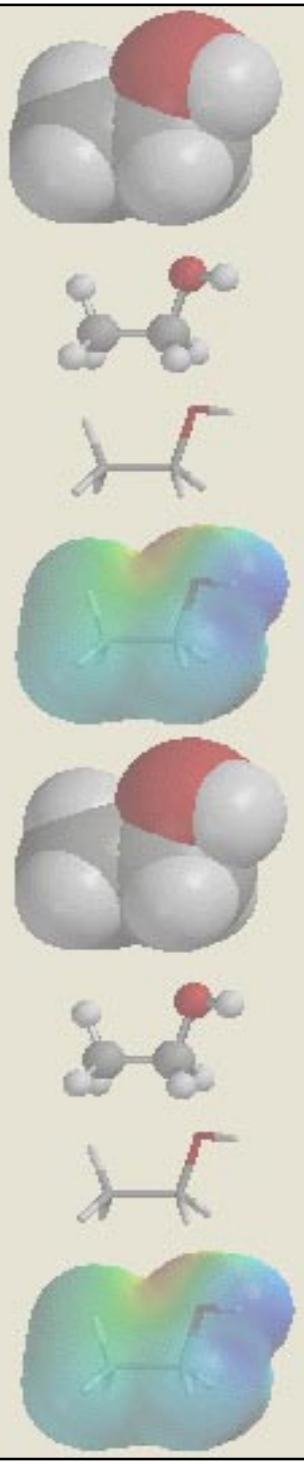
Classify each of the following properties as physical or chemical. Explain your reason for each.

a. Iron melts at 1535°C.
b. Alcohol is very flammable.
c. The metal used in artificial hip-joints implants is not corroded by body fluids.
d. A 1-in. cube of aluminum weighs less than 1-in. cube of lead.
e. Gasoline burns readily.



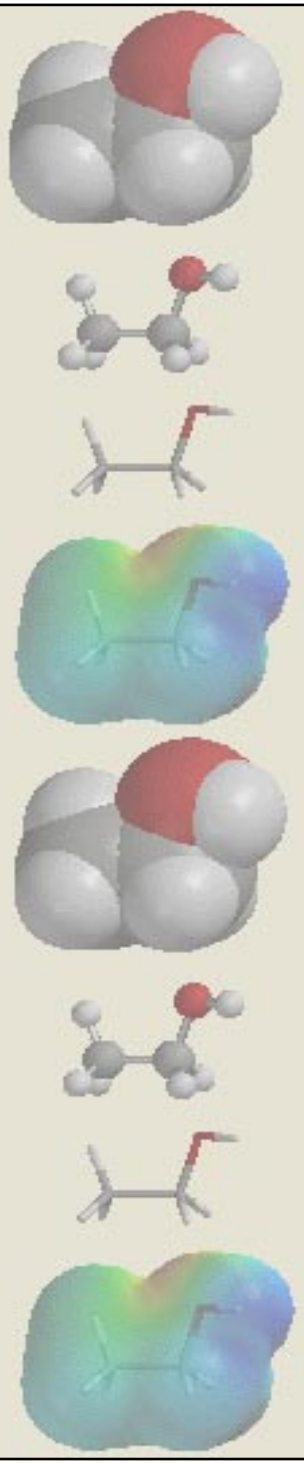
A Model of Matter

- Scientific models are used to help us "visualize" and understand the behavior of nature.
- Models are devised through and iterative process of
  - Scientific observation
  - Formulation of hypotheses
  - Testing of hypotheses



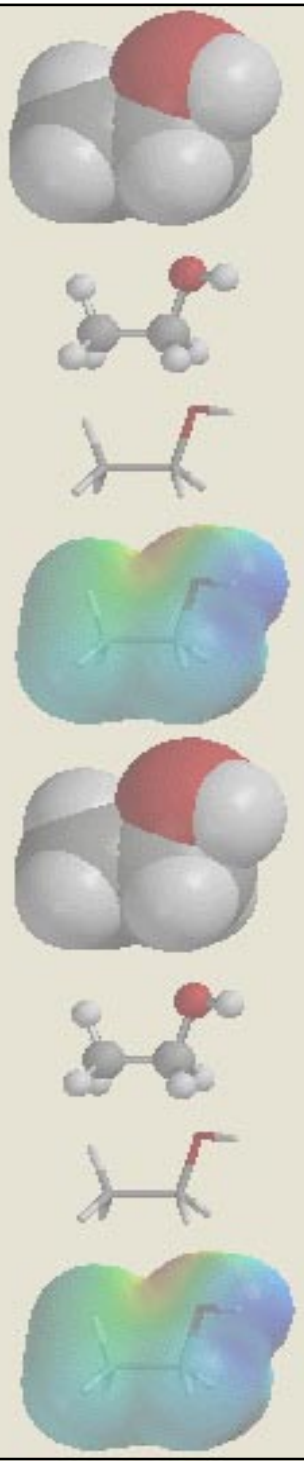
Observations about Gases

- At constant temperature the volume of a gas changes with pressure:
  - Increasing pressure decreases volume
  - Decreasing pressure increases volume
- At constant volume the pressure of a gas changes with temperature:
  - Increasing temperature increases pressure
  - Decreasing temperature decreases pressure



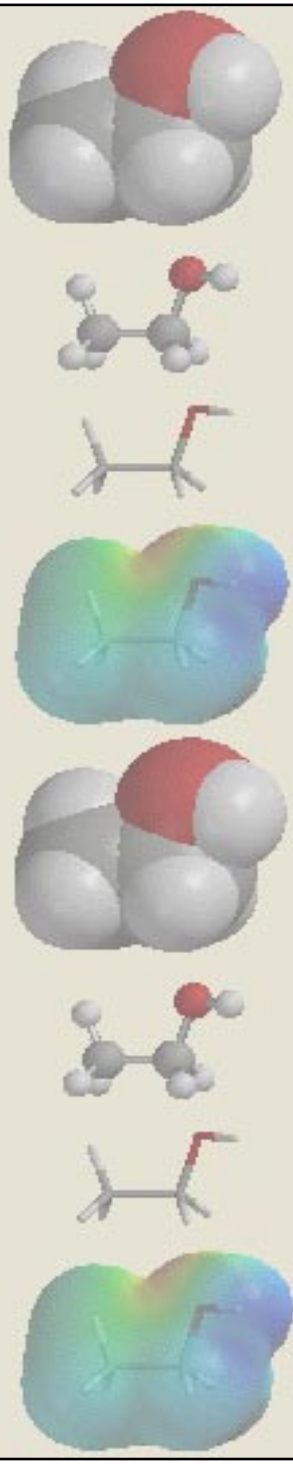
Observations about Gases

- Gases have mass.
- Gases mix rapidly with one another when brought together.



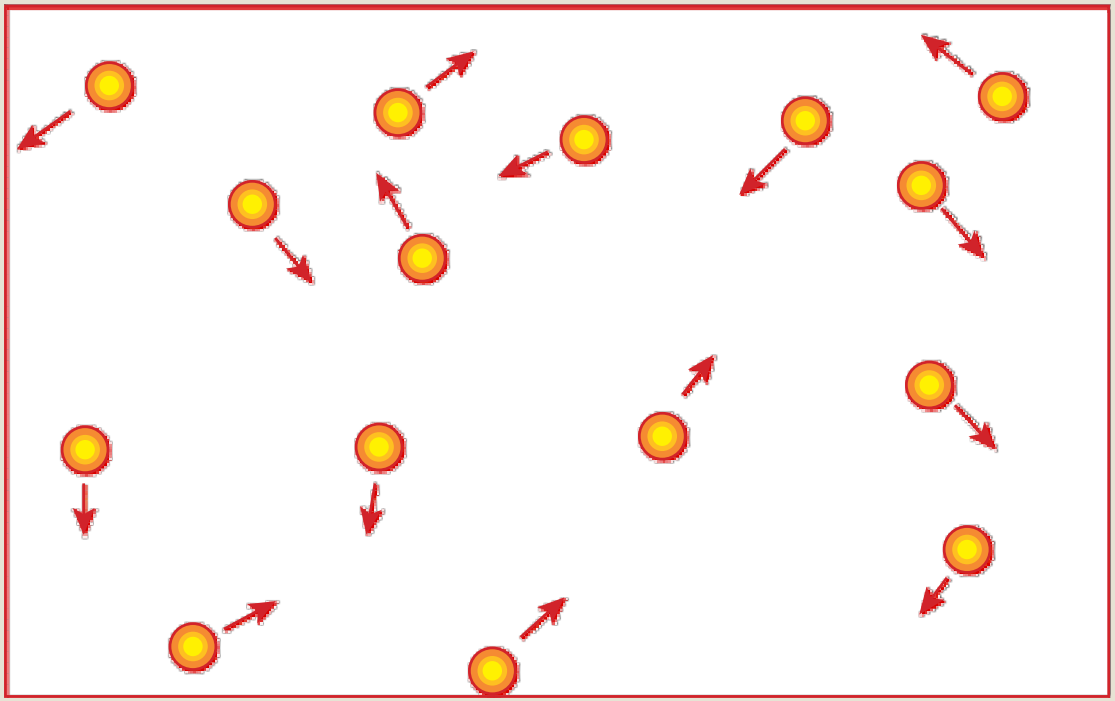
A Model of Matter

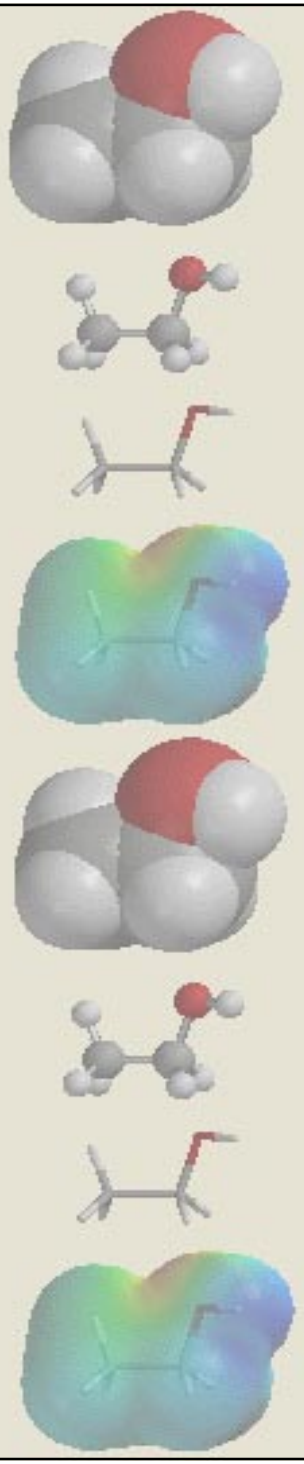
- All matter is made up of very tiny particles.
  - Early on these particles were called *molecules*.
- We now know that molecules make up many, but not all, substances.
  - For now we will consider only those substances that are made up of molecules.



A Model of Matter

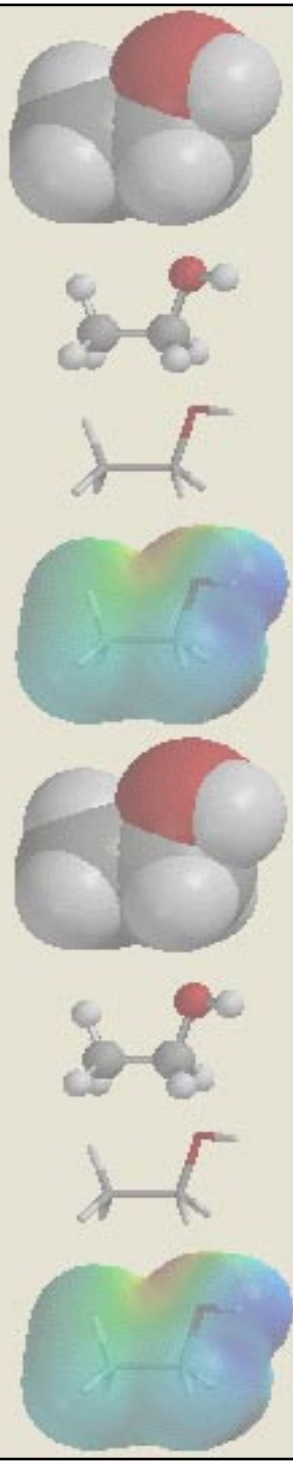
- For gases, these molecules move rapidly about colliding with each other and with the walls of the container:





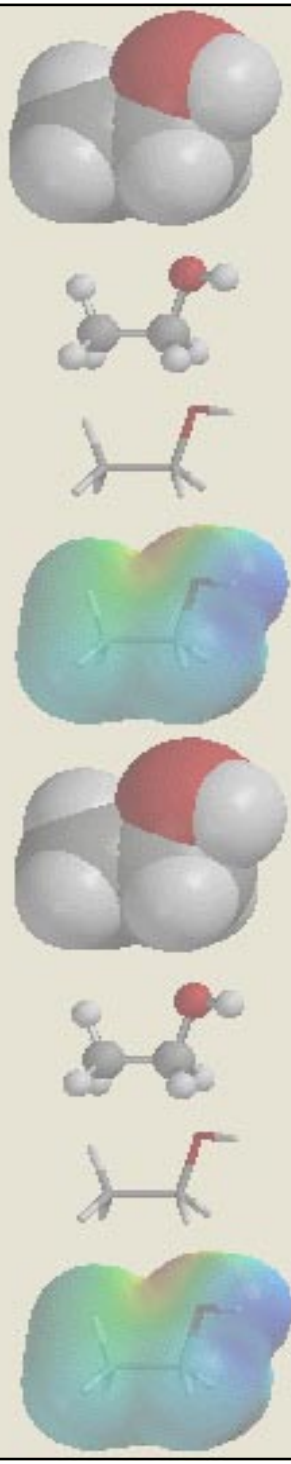
A Model of Matter

- A **molecule** is the smallest particle of a *pure substance* that has the properties of that substance and is capable of stable independent existence.
- A **molecule** is the limit of *physical* subdivision of a *pure substance*.
  - Any further subdivision can only be done chemically, by changing the composition of the substance.



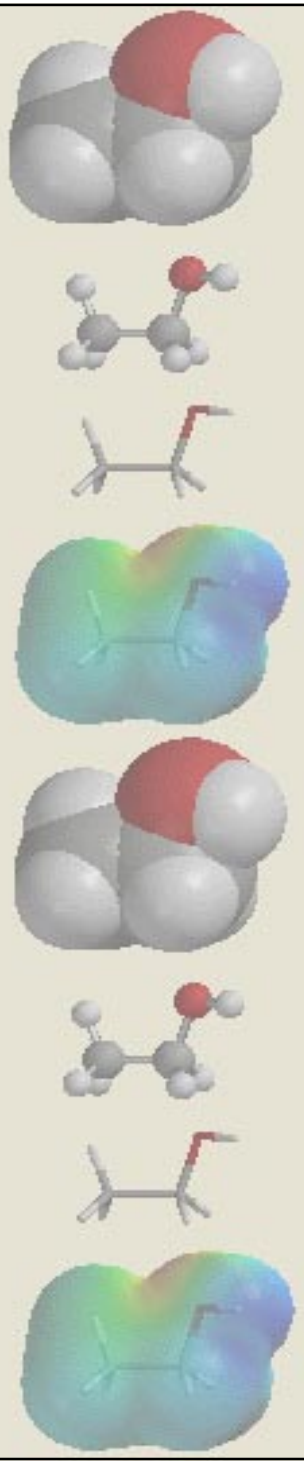
A Model of Matter

- A molecule can be *chemically* separated into smaller particles called atoms.
  - Circles are often used to graphically represent atoms:



Types of Molecules

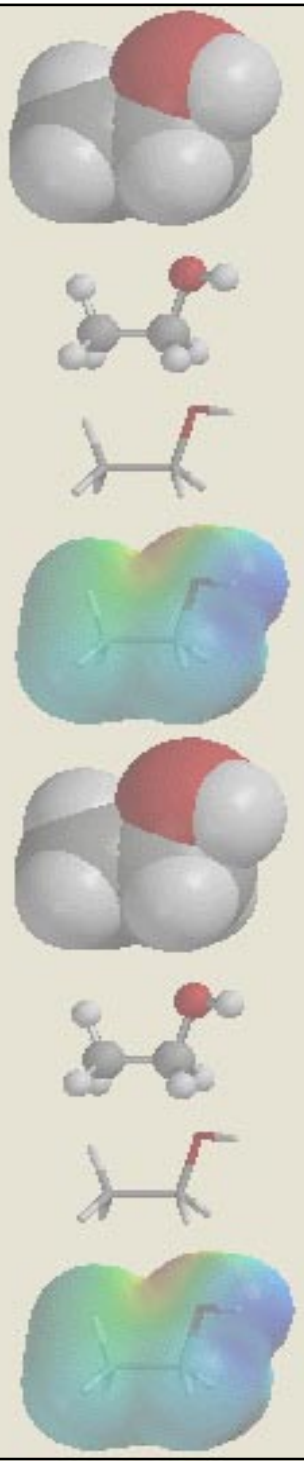
- Diatomic
  - Contain two atoms
- Triatomic
  - Contain three atoms
- Polyatomic
  - Contain more than three atoms
- Homoatomic
  - Contain only one type of atom
- Heteratomic
  - Contain more than one type of atom



Exercise 1.13

A sample of solid elemental (homoatomic) phosphorus that is deep read in color is burned. While the phosphorus is burning, a white smoke is produced that is actually a finely divided solid. The white solid is collected.

a. Have the molecules of phosphorus been changed by the process of burning? Explain.
b. Is the collected white solid a different substance from the phosphorus? Explain.
c. In terms of the number of atoms contained, how do you think the size of the molecules of the white solid compares with the size of the molecules of phosphorus? Explain.
d. Classify the molecules of the collected white solid using the terms *homoatomic* and *heteroatomic*. Explain your reasoning.

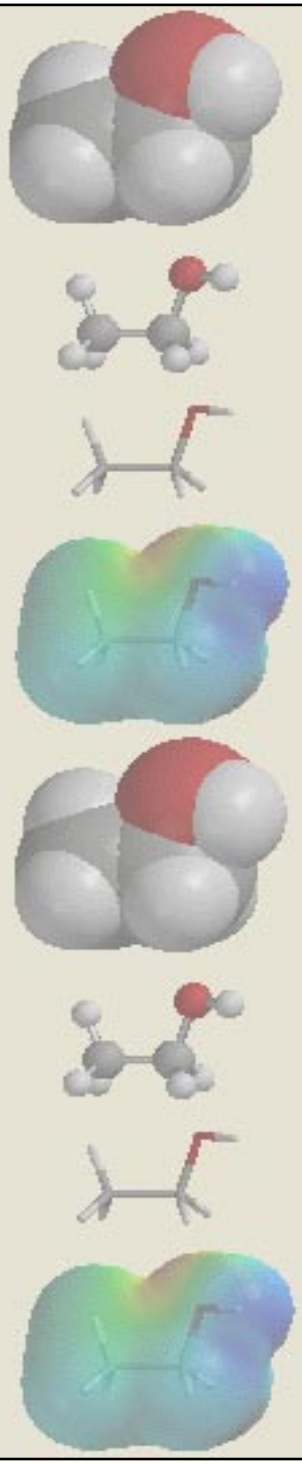


Classification of Matter

- Given a sample of matter,
  - Is it a *pure substance*

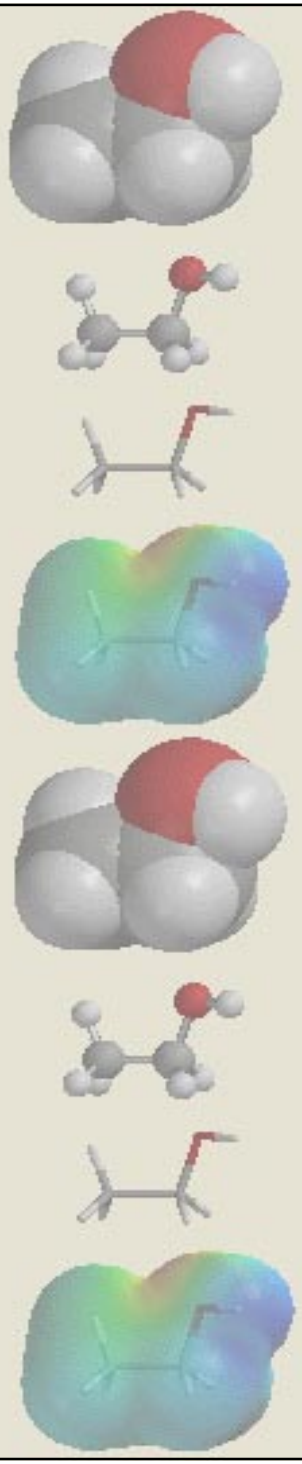
    or

  - Is it a *mixture*
- It has to be *one* **or** the *other*



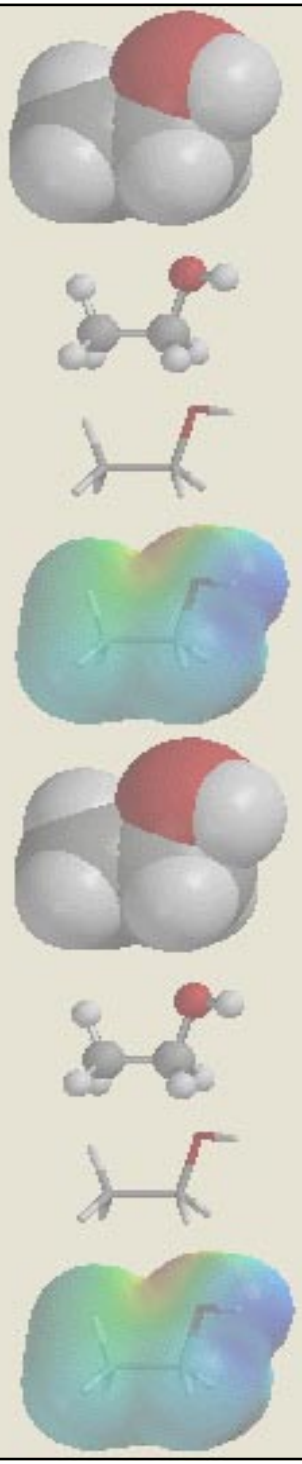
Pure Substances

- A **pure substance** is matter that has a constant composition and fixed properties.
- This is because all of its molecules are identical.
- Oxygen, carbon dioxide, water sucrose and aluminum are examples of pure substances.



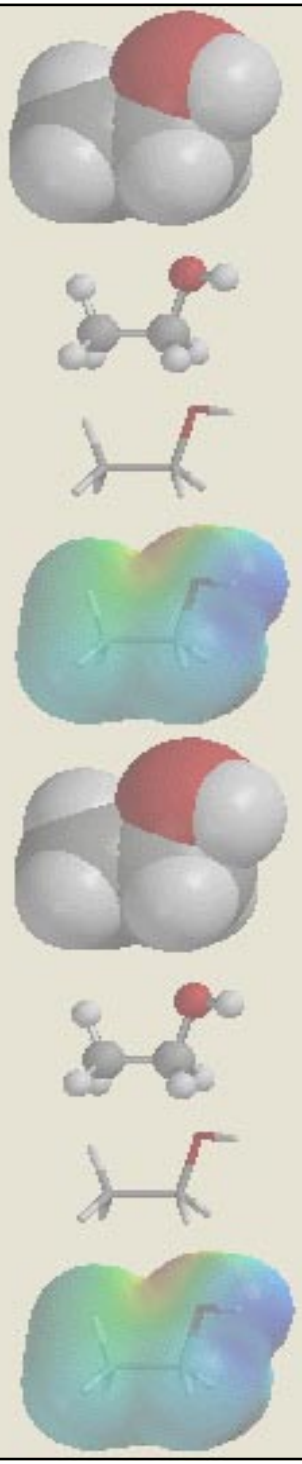
Mixtures

- A **mixture** is a physical blend of matter that can be physically separated into two or more components, which are themselves pure substances.
- In a mixture not all of the molecules are identical.
- Air, sugar water and steel are examples of mixtures.
- Most samples of matter are mixtures.



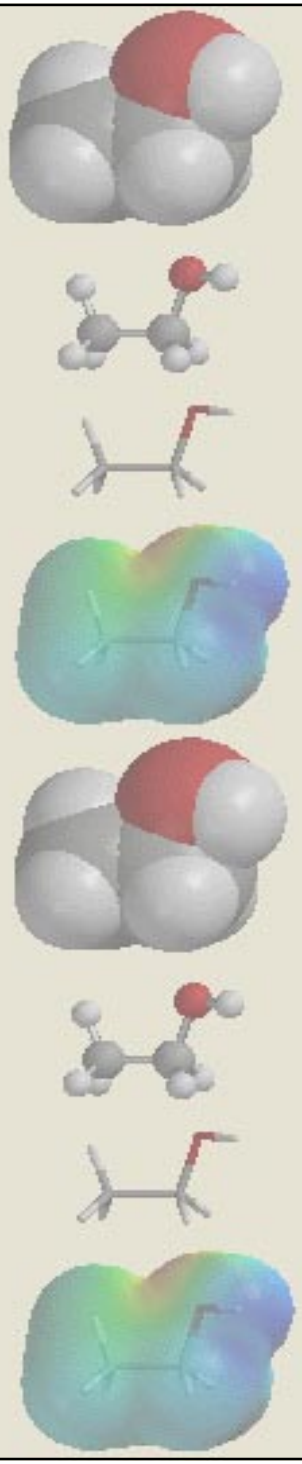
Pure Substances *vs.* Mixtures

- Pure substances have a fixed set of physical properties
- The physical properties of mixtures depend on the relative amounts of its components.
- The physical properties of a mixture resemble an average of the physical properties of its constituent components.
  - In a mixture the components do not lose their physical identity.



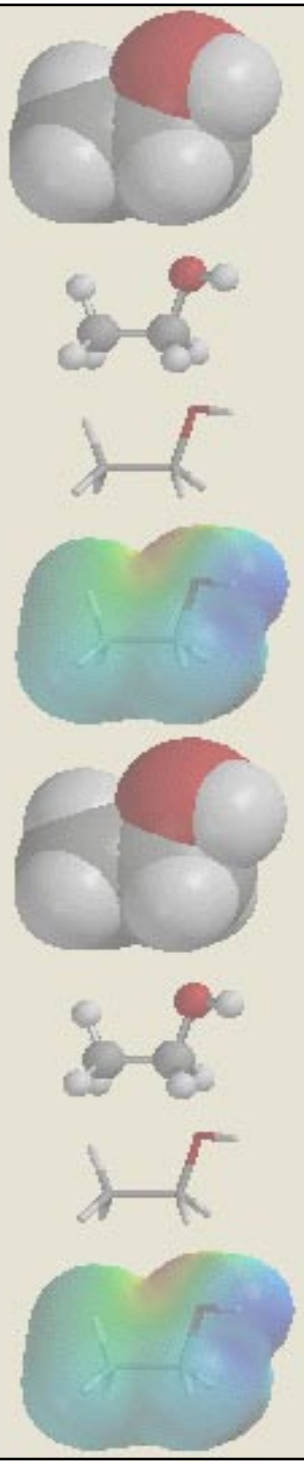
Classification of Matter

- **Homogeneous** matter has the same properties throughout the sample.
  - All pure substances are homogeneous.
- **Homogeneous mixtures** are called solutions.
  - Sugar water is a homogeneous mixture (solution).
- Mixtures that are not homogeneous are heterogeneous mixtures.
  - A mixture of sand and sugar is a heterogeneous mixture.



Classification of Pure Substances

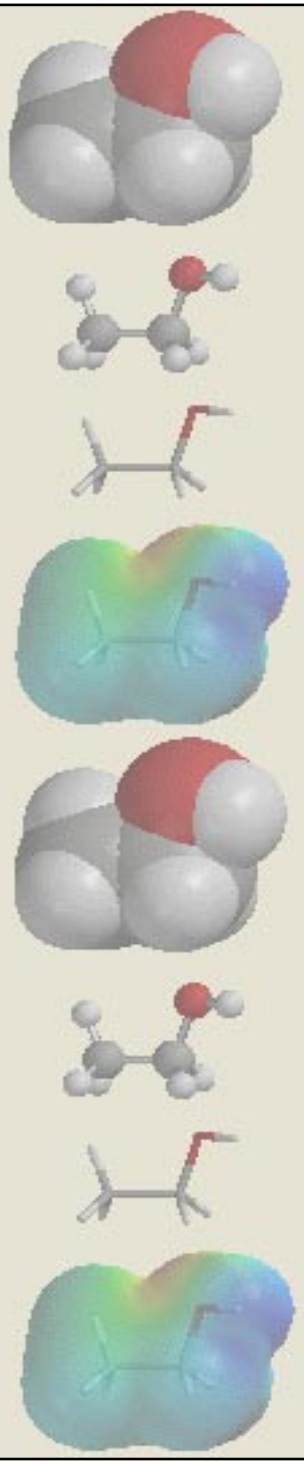
- **Elements** are pure substances that are made of *homoatomic* molecules.
  - Oxygen, nitrogen, carbon and mercury are examples of elements.
  - The **periodic table** is an arrangement of all the elements.
- **Compounds** are pure substances that are made of *heteratomic* molecules.
  - Carbon monoxide, carbon dioxide, water and sugar are examples of compounds.



Exercise 1.19

Classify each pure substance represented below by a capital letter as an element or a compound. Indicate when such a classification cannot e made and explain why.

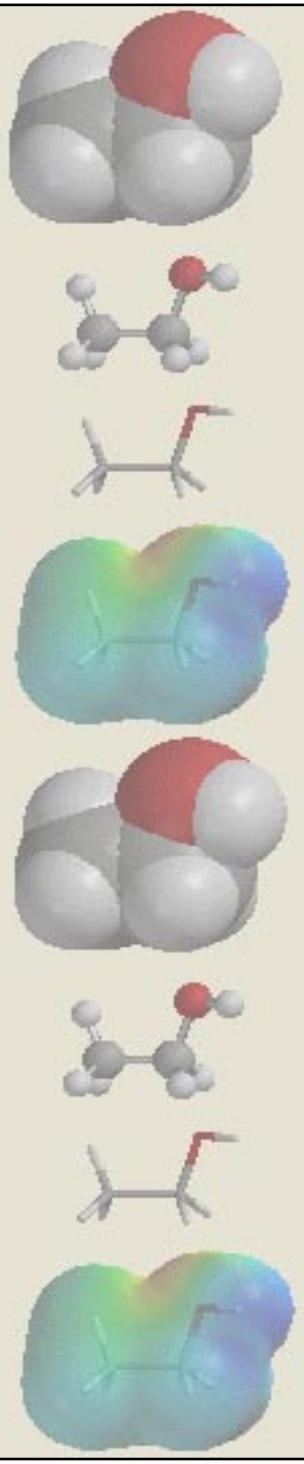
a. Two elements when mixed combine to form only substance **L**.
b. An element and a compound when mixed form substances **M** and **Q**.
c. Substance **X** is not change by heating.



Exercise 1.23

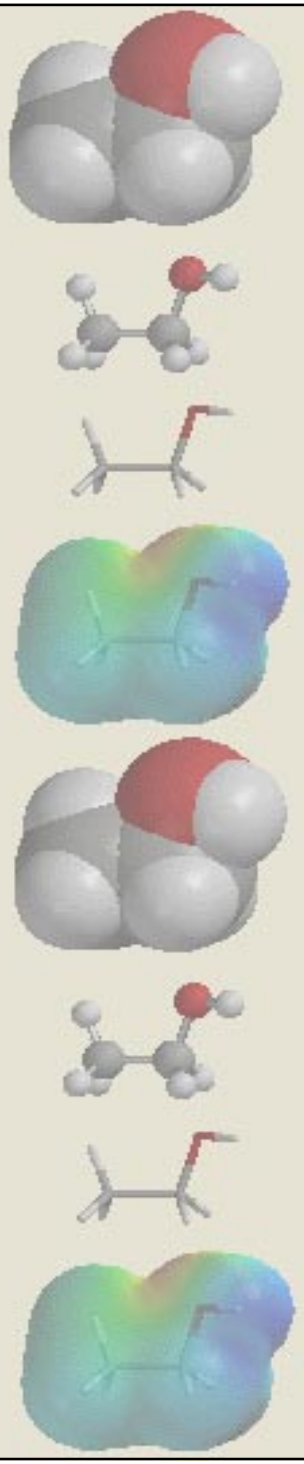
Classify each of the following as homogeneous or heterogeneous.

a. Muddy flood water.
b. Gelatin dessert.
c. Normal urine
d. Smog-filled air
e. An apple
f. Mouthwash
g. Petroleum jelly.



Measurement Units

- Units give numbers meaning
  - 1 meter
  - 10 pounds
  - 23 seconds
- Nearly all of the numbers we will be working with have units.
  - If you fail to give the units for these numbers they will be meaningless!
  - Advice: *Do not give meaningless answers to problems*.



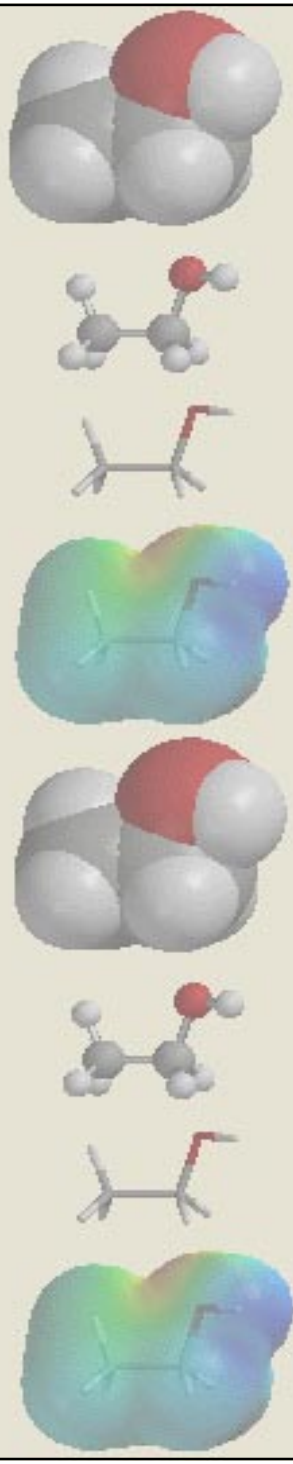
The metric system

- We will be using the metric system of units.
- Like our number system, the metric system is a *decimal* system.
- It contains only a few **basic** units
  - These include:

    Mass - gram

    Length - meter

    Time - second



The metric system

- Most of the units in the metric system are **derived** units:
  - Area - *meter* x *meter* = m^2
  - Volume - *meter* x *meter* x *meter* = m^3
  - Velocity - $\frac{meter}{second} = m/s$
  - Energy -

$$\frac{kilogram \text{ x } meter \text{ x } meter}{second \text{ x } second} = kg\,m^2/s^2 = Joule$$