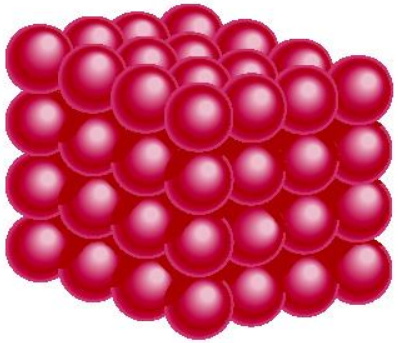
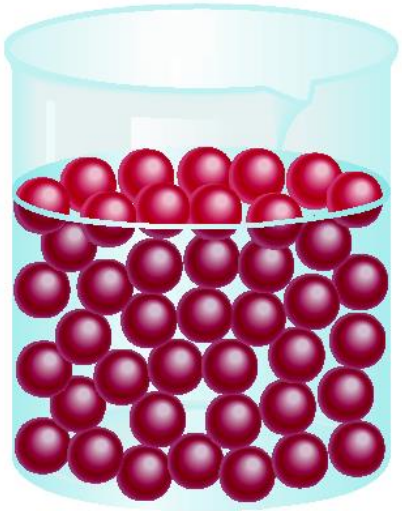
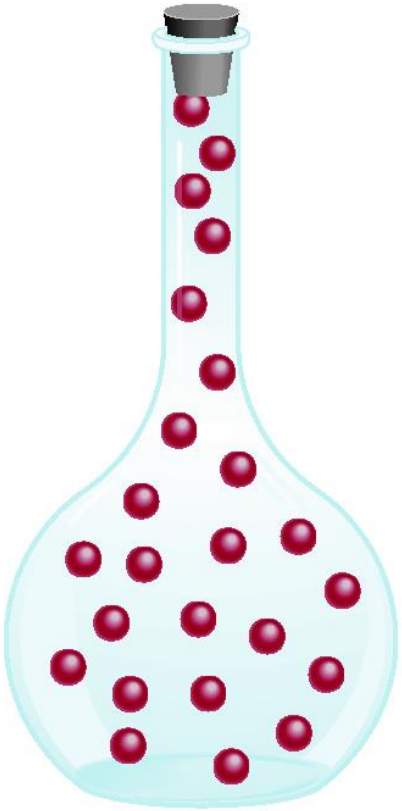
A Comparison: The Three States of Matter



Solid



Liquid



Gas

Example: ICE → WATER → WATER VAPOR

Temperature

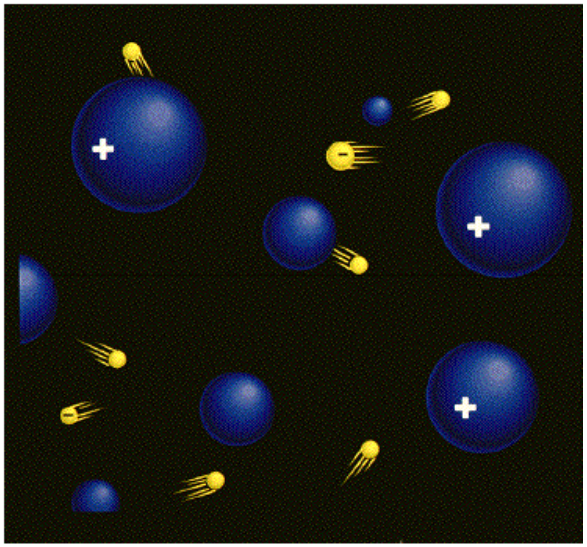
- **Ordinary matter is made of particles - atoms or molecules.**

- **Particles of matter are in constant motion** (*vibrating* in place in solids, *sliding past each other* in liquids, *flying around freely* in gases)**, but they don't all move at the same speed and in the same direction all the time.**
- **<u>Temperature</u> is a measure of the *average* energy associated with *random motion* of the particles of a substance.**
- **The higher the temperature of an object, the faster on average its particles move.**

But what happens if you raise the temperature to super-high levels... between 1000°C and 1,000,000,000°C ?

Will everything just be a gas?

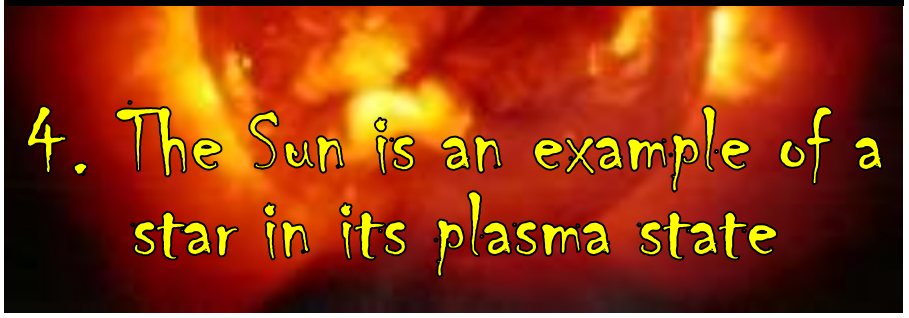
PLASMA



- **A plasma is an ionized gas:**
  positively charged nuclei swim in a "sea" of freely-moving dissociated electrons.
- **A plasma is a very good conductor of electricity: it produces and responds to magnetic fields.**
- **Plasmas, like gases, have an indefinite shape and an indefinite volume.**
- **A gas is usually converted to a plasma in one of the following two ways:**
  - **from a huge voltage difference between two points**
  - **by exposing gas to extremely high temperatures that cause electrons to leave the atoms**

Plasma is a common state of matter!

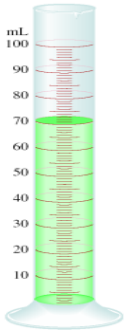
Some places where plasmas are found…



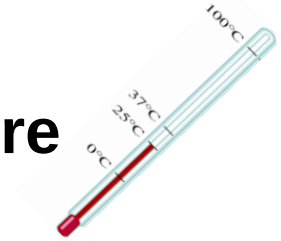
Physical Properties of Matter

We can describe <u>physical properties</u> of matter in terms of physical quantities and laws.

- **An *<u>extensive</u>* property depends upon how much matter is being considered:**
  - **mass**
  - **volume**
  - **electrical charge**



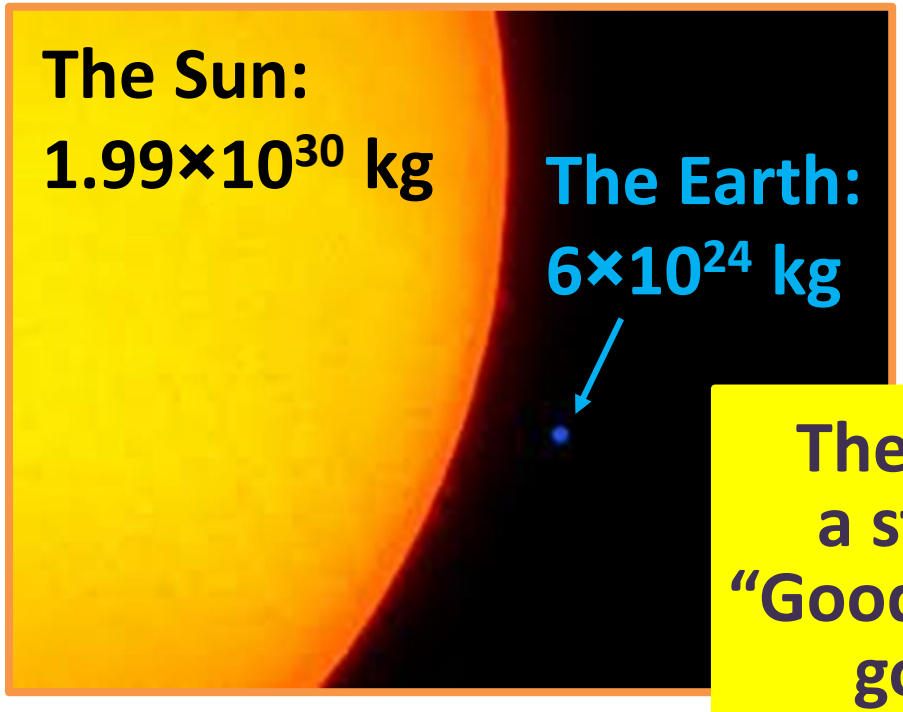
- **An *<u>intensive</u>* property does *<u>not</u>* depend upon how much matter is being considered:**
  - **density**
  - **temperature**
  - **color**

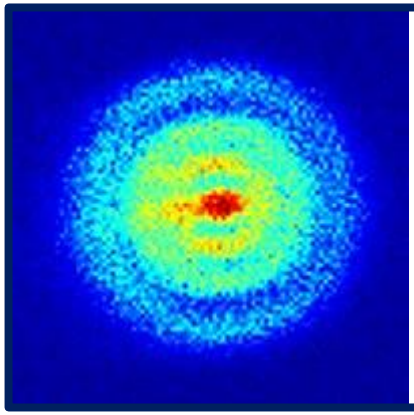


  - **elasticity**
  - **metallicity**
  - **solubility etc…**

Mass

- **Mass** is the **amount of material** in an object (doesn't change).
- Don't confuse with **weight**, a measure of how strongly gravity is pulling on an object (decreases as elevation increases).



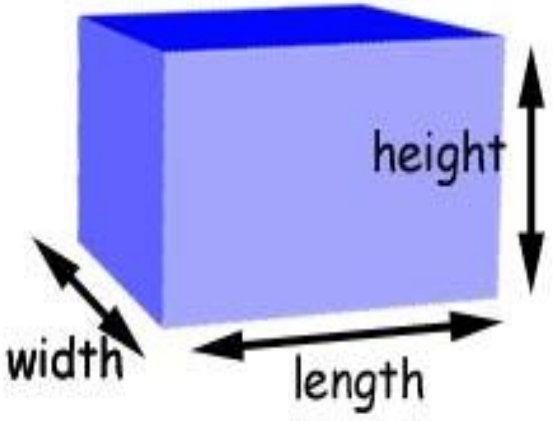


The mass of a smallest atom, Hydrogen, is 1.67×10^{-27} kg

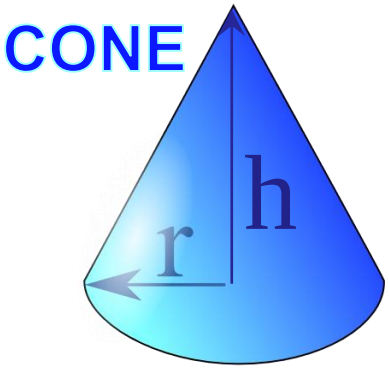
The mass of a standard "Good Delivery" gold bar is 12.4 kg

- **SI unit of mass is kg**

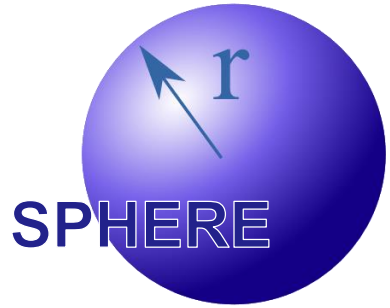
Volume



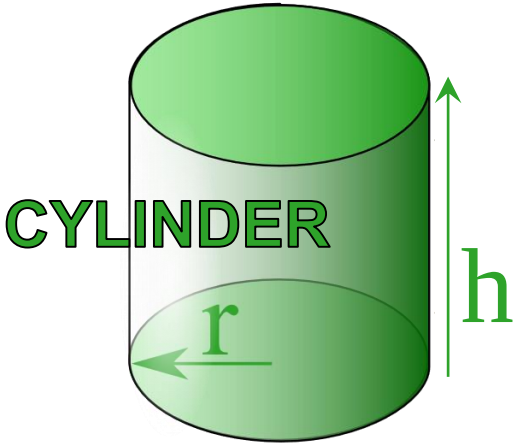
- **Volume is the amount of three-dimensional space that a substance or shape occupies or contains.**
- **SI unit of volume is m^3**
- **$V_{rectangular\ prism}$ = length × width × height**



$$\left(\frac{1}{3}\right)\pi r^2 h$$



$$\left(\frac{4}{3}\right)\pi r^3$$



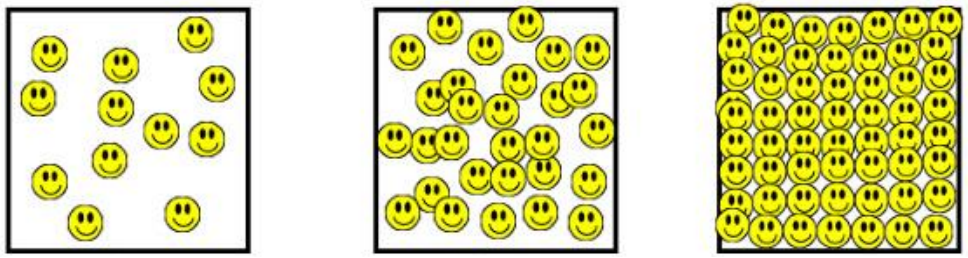
$$\pi r^2 h$$

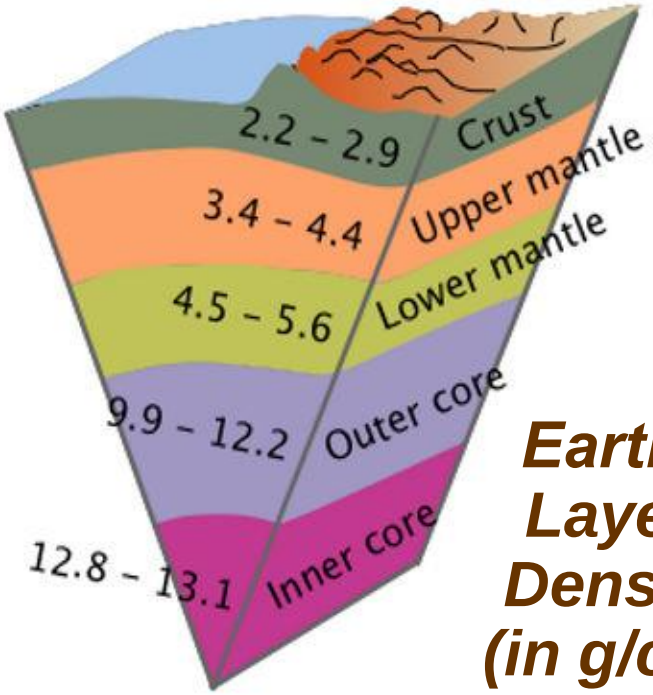
Where r = radius, h = height, and π = 3.14

Density

- **Density is a measure of <u>how much matter is contained in a unit of volume</u>:**

  - **density = $\frac{\text{mass}}{\text{volume}}$**
  - **SI unit is kg/m^3**





Earth's Layers Density (in g/cm^3)

- **The density of a material varies with temperature and pressure** (this variation is typically small for solids and liquids but much greater for gases).
  - **In general, lowering the temperature results in density increase**
  - **Increasing the pressure also results in density increase**

How many states of matter can you find in each picture?