All ordinary matter is made of sub-microscopic particles called **atoms**. An atom is the simplest form of an **element**. There are more than one hundred different elements. The elements are conveniently arranged in the rows and columns of the **Periodic Table**.

Lead is an element. A piece of lead is composed of atoms. Every atom is an atom of lead. So what makes an atom of lead different from an atom of, say, iron?

If we look at the Periodic Table, we see that lead (which has the symbol 'Pb') is element #82. Iron (Fe) is element #26. 82 and 26 are the **atomic numbers** of lead and iron, respectively.

To explain further, we must look at the structure of an atom. Atoms are composed of a **nucleus** surrounded by **electrons**. The nucleus consists of a tightly packed collection of **protons** and **neutrons**. These three **sub-atomic particles** are characterized by two properties, **mass** and **charge.**

Particle	Mass*	Charge
Proton	1 amu	+1
Neutron	1 amu	0
Electron	0 rest mass	-1

- 1 amu = 1/12 the mass of carbon-12 or 1.66 x 10^{-24} gram
- The electron travels at the speed of light and its mass equivalent is 9.109 x 10^{-28} g or 0.000549 amu

Let's add to this another important particle, the photon, a particle of radiant or electromagnetic energy traveling at the speed of light that may interact with electrons:

Photon	0 rest mass	0

Back to elements: An element is characterized by its atomic number which is equal to the **number of protons in its nucleus**. Thus the nucleus of lead contains 82 protons and the nucleus of iron contains 26 protons.

The other number found alongside each element of the Periodic Table is the **atomic mass** (or weight) of the element. The atomic masses of lead and iron are 207.2 amu and 55.85 amu, respectively. Why the fractional numbers? Because the atomic mass is actually an average of the masses of the different **isotopes** of the element. Isotopes of lead, for example, have the same number of protons but **different numbers of neutrons.** Most elements have more than one isotope. Fluorine is an exception. Naturally-occurring fluorine has exactly 9 protons and 10 neutrons in its nucleus and has an atomic mass of 19.00 amu.

Chlorine is composed of Cl-35 and Cl-37 in a ration of about 3-to-1. The average atomic mass of a large collection of chlorine atoms is calculated by taking the weighted average:

$$(0.75) \times 35 + (0.25) \times 37 = 35.5 \text{ amu.}$$

Bromine contains approximately equal numbers of Br-79 and Br-81. What is its average atomic mass?

A neutral atom has equal numbers of protons and electrons. If the atom has an excess of electrons, then it takes on a net negative charge. If the atom has fewer electrons than protons in the nucleus, then it takes on a net positive charge.

The elements of the Periodic Table can be grouped into four types: metals, nonmetals, metalloids, and noble gases. Metals occupy the left and bottom regions, nonmetals occupy the upper right region, and metalloids – which behave chemically as either metals or nonmetals – are along the line separating metals from nonmetals. The noble gases are restricted to the far right-hand column.

The Main Group Elements are those in Groups IA through VIIIA. Group IA (except for hydrogen, H) represents a family of metals that behave similarly called the **alkali metals**: Li, Na, K, Rb, Cs, Fr. Group IIA – Be, Mg, Ca, Sr, Ba, Ra – are the **alkaline earth** metals. Grup VIIA – F, Cl, Br, I, At – are known as the **halogens**. The other main groups also represent families

Metals in the B groups are called **transition elements.**

Quantum Theory says that the electrons of an atom are restricted to certain specific energies and that energies in between these permitted levels are forbidden. The possibility of locating an electron in space is impossible according to the **Heisenberg Uncertainty Principle** and so we are limited to discussing the electron in terms of the probability of finding it in a particular region of space. Thus we are forced to discuss the electron in terms of mathematical probabilities. And so we say that the electron occupies an **orbital**, an orbital being a mathematical probability function.

The Schrödinger equation which assumes that the electron behaves like a wave, or even like a twanging guitar string, can be solved exactly for only one atom, the hydrogen atom. But the results are applicable to all of the atoms of the Periodic Table.

The hydrogen atom consists of one proton and one electron. The permitted energy levels are described by four quantum numbers. The **Pauli Exclusion Principle** holds that the every electron of an atom must have a different set of the four numbers and that the maximum number of electrons per orbital is two.

This sounds complicated but it establishes a pattern for the way the electrons are distributed within an atom that is quite straightforward and remarkably symmetrical. The electrons must obey very strict rules!

First shell: There is only one orbital and it is designated **1s.** It may hold 2 electrons.
Second shell. There is one s orbital and 3 p orbitals. Maximum number of electrons = 2 + 3 x 2 = 8.
Third shell. One s orbital, 3 p orbitals and 5 d orbitals. Maximum number of electrons = 18.
Fourth shell. One s orbital, 3 p orbitals, 5 d orbitals and ____________(fill in the blank) f orbitals.
Maximum number of electrons = ?

Actually the order in which the electrons fill gets a little tricky after a while because the 4s orbital usually occupies a slightly lower energy than the 3d orbital. Figure 2.6 in the text is a device for figuring out the usual order of filling. Examples will be given in class of two styles of showing the arrangement of the electrons of a particular element.

Most of chemistry, and this is a very general statement of fact, involves the electrons in the outermost shell of the atom. These are called the **valence electrons**. Because they are the ones that do the business of chemistry, it is useful to ignore those in the inner shells and to show the elements as electron-dot symbols. And here is your bonus factoid: For the main group elements (IA-VIIA), **the number of valence electrons is equal to the group number.** The chemistry of the transition metals (Groups IB-VIIIB) is a little more complicated.

The Periodic Table can now be divided into four different areas based on the subshell designation of the element's valence electrons: There are the s-block, p-block, d-block, and f-block elements (Figure 2.7). The d-block elements are the **transition metals which are characterized by partially filled d orbitals**.

Other topics:
The electromagnetic spectrum (p. 66).
Electron dot symbols (p.65).

To be omitted: discussion of Figures 2.3 and 2.4 involving atomic radii.

Homework Assignment (due Wednesday, 4 February):

2: 45,47,49,53,57,61,73,77,79,87,89,95,99,103,105.