Most of the Universe consists of matter and energy. Energy is the capacity to do work. Matter has mass and occupies space. All matter is composed of basic elements. Elements are substances consisting of one type of atom.

For example pure (24K) gold is composed of only one type of atom, gold atoms. Atoms are the smallest particles into which an element can be divided.

We now know that the atom is divisible, often releasing tremendous energies as in nuclear explosions or (in a controlled fashion in) thermonuclear power plants.

Chapt. 2
The Nature of Molecules

- All organisms are made up of cells
- All cells made of macromolecules
- All macromolecules are collections of smaller molecules
- All molecules are collections of atoms

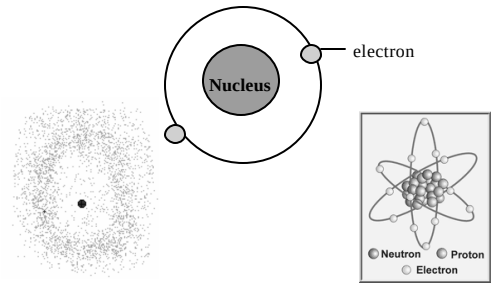
Life & Matter

- All living things are made of matter
- All matter is composed of Atoms.

Atoms

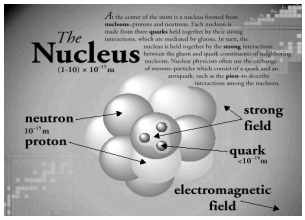
- 1913 Niels Bohr described the atom as a central core (nucleus) surrounded by an orbiting cloud of electrons
- Likened to planets orbiting a sun
- Nucleus is the sun, electrons are the planets

The Atom:
3 Views



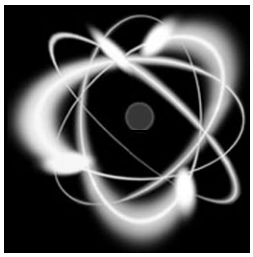
The Nucleus

- Composed of (+) charged protons,
- And, neutral (0) charged neutrons
- (Protons and neutrons themselves are composed of even smaller subatomic particles termed quarks)
- Protons and Neutrons are heavy, Electrons are light….



Electrons

- Carry a (-) charge
- Are small and light compared to the protons and neutrons



The Electron

It has a mass of $9x10^{-31}$ kg or 1 two thousandth of the mass of a proton (or one million millionth of the mass of a speck of dust).

The electron carries a precise charge of $1.6x10^{-19}$ coulombs.

All attempts to measure the radius of the electron have failed! All we know is that the radius is less than 10^{-18} m; that is, its radius is one hundred million times smaller than that of the atom. All the known properties of the electron are consistent with the assumption that its radius is zero…

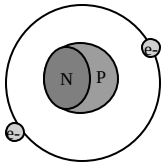
As far as we know, the electron has no structure.

- All subatomic particles have a mass and can be measured
- Mass is different from weight
- Read Text pg. 17 (section on Atoms)….

Atomic Mass

- Measured in units called Daltons (D)
- 6 x 10^{23} Daltons = 1 gram
- 1 proton weighs 1D
- 1 neutron weighs 1D
- Electrons (e-) have a mass ~1/2,000 D
- Therefore we consider the e- to be almost massless

e-



e- =Electron (massless)

P= Protons (1 D each)

N= Neutrons (1D each)

Atomic Mass of any atom...

- Is equal to the number of protons plus the neutrons
- The electrons weigh too little to count…

$$A_{number}^{mass}\ {}^{14}_{6}C$$

$$Z_{number}^{atomic}$$

$$N_{number}^{neutron} = A - Z$$

What would be the atomic mass of an atom with 1p and 1 n?

With 6p and 8n?

Atomic Charge

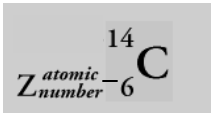
- Typically, atoms carry a neutral charge….
- Meaning.. the number of protons (p) and electrons (e-) are equal.
- So that, for each proton in the nucleus, there circles 1 electron
- For neutrally-charged atoms, one can always know the number of e- if one knows the number of p ….

Atomic Number

- A number expressing the number of p for any given atom
- At. No. is characteristic for any different type of atom and determines that atom's name
- Naturally occurring atoms have At. No. from 1-92
- These are the 92 natural *elements* of the Universe

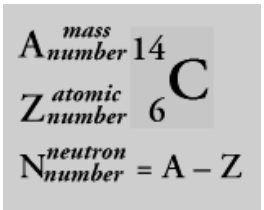
Atomic Number

- Atoms with the same At. No. are the same elements
- At. No. = 1 ….. H
- At. No. = 13 …. Al
- At. No. = 79 …. Au
- At. No. = 92 …. U



Quiz

- How many protons does each atom of Gold contain?
- How many Protons do Uranium atoms contain?
- If an Aluminum atom is neutrally charged, how many e- does it contain?



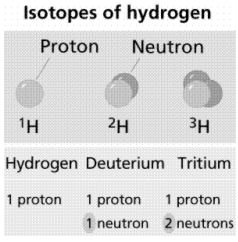
- The nucleus depicted is understood to be a quantum system composed of protons and neutrons, particles of nearly equal mass and the same intrinsic angular momentum (spin) of 1/2.
- The proton carries one unit of positive electric charge while the neutron has no electric charge.
- The simplest nucleus is that of hydrogen, which is just a single proton, while the largest nucleus studied has nearly 300 nucleons. A nucleus is identified as in the example below by its atomic number Z (*i.e.*, the number of protons), the neutron number, N, and the mass number, A, where $A = Z + N$.
- The convention for designating nuclei is by atomic number, Z, and mass number, A, as well as its chemical symbol. The neutron number is given by $N = A - Z$.

Isotopes

- All atoms with the same number of protons belong to the same element...
- Elements may, however, have ***different*** numbers of neutrons
- Elements with different numbers of neutrons are termed *isotopes* of that element

Isotopes of Hydrogen

- What is the At. No. of Hydrogen?
- How many p's does it have?
- How many n's?
- Text pg. 19
- H may have 0, 1 or 2 n's
- There are 3 isotopes of Hydrogen



Quiz

- What is the *Atomic Mass* of each isotope of Hydrogen?
- Isotopes written as such:

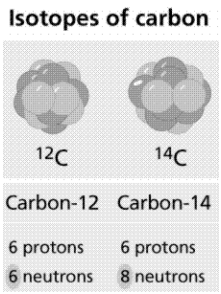
H (Hydrogen)

^{2}H (Deuterium)

^{3}H (Tritium)

Isotopes of Carbon

- Isotopes exist naturally and may be common
- Carbon-12 (^{12}C) most abundant
- Contains 6p & 6n
- Carbon-13 a stable isotope
- Carbon-14 unstable (radioactive)



Radioactive Isotopes

- Unstable isotopes which spontaneously break down to lower At. No. elements and release energy during radioactive decay

Quiz

- How many p's and n's does Carbon-14 possess?
- Text pg. 19

Review

- The number of protons determines the type of element (H, C, Au,U..)
- The number of neutrons determines the isotope of that element…..

Add to this….

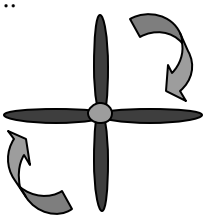
- The *electrons* determine the chemical properties of any element.

Electrons

- e- orbit around the central core (nucleus) of an atom
- If the atomic nucleus were the size of a marble, the nearest e- would be spinning in a circle as wide as…
- A football field!!
- Atoms are mostly empty space!

Atoms are mostly empty space!

- Why can't we pass through this space?
- Consider a fan….



Electrons are far outside the nucleus, spinning rapidly

- This explains why atomic nuclei rarely interact in nature…
- and never interact in biological systems
- It is the whirling outer e- who do all the interactions….
- e-/e- interactions are responsible for the chemistry of life