1.5. Measuring Units on the Atomic Scale

The size and mass of atoms are so small that the use of normal measuring units, while possible, is often inconvenient.

First, the conventional unit of mass, the kilogram, is rather large for use in describing characteristics of nuclei. For this reason, a special unit called the Atomic Mass Unit (amu or u) is often used. This unit is defined as 1/12th of the mass of the stable most commonly occurring isotope of carbon, ^{12}C. In terms of grams, units of measure have been defined for mass and energy on the atomic scale to make measurements more convenient to express. One atomic mass unit is equal to1.66 x 10^{-27} *kg*.

Second, the unit for energy is the electron volt (eV); the electron volt is the amount of energy acquired by a single electron when it falls through a potential difference of one volt. Energy of one electron volt is equivalent to 1.602 x 10^{-19} joules.

Third, the unit of the size of the atom, comes from the radii of nuclei and atoms, is Fermi (fm), where $1fm=10^{-15}$ m $= 10^{-13}$ cm.

1.6. Equivalence of Mass and Energy

The great theory of 20th century physics that is indispensable to the development of atomic and nuclear physics is the special theory of relativity proposed by Einstein in 1905. The first applications of the relativity theory depend on two closely related ideas. One idea is that of the variation of mass of a particle with its velocity; the second is that of the proportionality between mass and energy, so that the mass can be considered to be as another form of energy. Thus, the law of conservation of energy is really the law of mass-energy. In normal every day interactions, the amount of mass that is transferred into other forms of energy (or vice versa) is such a tiny fraction of the total mass that it is beyond our sensory perceptions and measurement techniques. Thus, in a chemical reaction, for example, mass and energy truly seem to be separately conserved. In a nuclear reaction, however, the energy released is often about a million times greater than in a chemical reaction, and the change in mass can easily be measured. The mass and energy are related by what is certainly the best-known equation in physics:

$$E = mc^2 \tag{1.10}$$

In which E is the energy equivalent called *mass energy* of mass m, and c is the speed of light.

A real understanding of this relationship can come only from a careful study of the relativity theory that is beyond the scope of this textbook. However, the main relationships of the special theory of relativity will be discussed.

After the problem raised by the Michelson-Morley experiment of propagation of light, Einstein interpreted their negative results to mean that it is indeed impossible to detect any absolute velocity through the ether. He deduced the time as the fourth dimension and found the interdependence between the space and time coordinates. One of the most important concepts developed in the original formulation of the relativity theory was the mass of a particle, as measured by an observer, was a function of its *velocity* υ relative to the observer. The term *relativistic mass* m, was used for the mass of a particle moving with relativistic speed, that is, a speed comparable to the *speed of light* c (3×10^8 m s^{-1}). The