1.3: Units of Measurement used in Atomic Physics

The energies of electrons are commonly measured and expressed in terms of a unit called an ***electron volt***. An electron volt (ev) is defined as the energy acquired by an electron when it is accelerated through a potential difference of one volt.

Imagine an evacuated tube which contains two parallel separate metal plates connected externally to a battery supplying a voltage *V*. The cathode in this apparatus, the negatively-charged plate, is assumed to be a photoelectric emitter. Photons from an external light source with a frequency n_o upon striking the cathode will supply the electrons with enough energy to just free them from the surface of the cathode. Once free, the electrons will be attracted by and accelerated towards the positively-charged anode. The electrons, which initially have zero velocity at the cathode surface, will be accelerated to some velocity u when they reach the anode. Thus the electron acquires a kinetic energy equal to ½ mu^2 in falling through a potential of *V* volts. If the charge on the electron is denoted by *e* this same energy change in ev is given by the charge multiplied by the voltage *V*:

(5)	$$\frac{1}{2}mv^2 = eV$$

For a given velocity u in cm/sec, equation (5) also (1.3.1) provides a relationship between the energy unit in the cgs (centimetre, gram, second) system, the erg, and the electron volt. This relationship is:

$$1\ ev = 1.602 \times 10^{-12}\ erg$$

The regular cgs system of units is inconvenient to use on the atomic level as the sizes of the standard units in this system are too large. Instead, a system of units called ***atomic units***, based on atomic values for energy, length, etc., is employed.

Atomic units are defined in terms of Planck's constant and the mass and charge of the electron:

$$Planck's\ constant = h = 6.625 \times 10^{-27}\ erg - sec$$
$$mass\ of\ electron = m = 9.108 \times 10^{-28} g$$
$$charge\ of\ electron = e = 4.8029 \times 10^{-10}\ esu$$

Length.

$$1\ au = a_0 = \frac{h^2}{4\pi^2 me^2} = 0.52917 \times 10^{-8}\ cm$$

Force. Force has the dimensions of charge squared divided by distance squared or

$$1\ au = \frac{e^2}{a_0^2} = 8.2377 \times 10^{-3}\ dynes$$

Energy. Energy is force acting through a distance or

$$1\ au = \frac{e^2}{a_0} = 4.3592 \times 10^{-11}\ erg = 2.7210 \times 10^{1}\ ev$$