1180: Electronic energy

(The concept of electronic energy is very important. Make sure to study it thoroughly, including the various related energies.)

Key words: Standards of electronic energy; position (potential) energy; relationship between force and energy; work; kinetic energy; uncertainty principle

Electronic energy refers to the energy possessed by an electron in an atom (or molecule, etc.).

[Energy]

Work (*W*) is force (*f*) ×distance (*s*). When work is applied to an electron, the electron has that amount of energy. The important thing here is to recognize that energy is the result of applying force to an object, not the cause (this is important in analyzing chemical phenomena).

The standard for energy is when the nucleus and the electron are infinitely far apart, and this is electronic energy = 0. The energy (*V*) of a substance that has received work is the accumulated force (*f*) × distance (*s*). If *f* is constant, then *V* = *fs*, but since *f* depends on the distance (*s*) from the nucleus and is a function of *s*, *f*(*s*), *V* takes the form of an integral. The magnitude of the energy (*V*) acting between two charges Q_1 and Q_2 at a distance *r* is expressed by the following equation.

$$V(r) = \int_{\infty}^{r} f(s)ds = \int_{\infty}^{r} k\frac{Q_1Q_2}{s^2}ds = k\frac{Q_1Q_2}{r}$$

Since this energy (*V*) is a quantity that is determined when a position *r* is given, it is called potential energy.

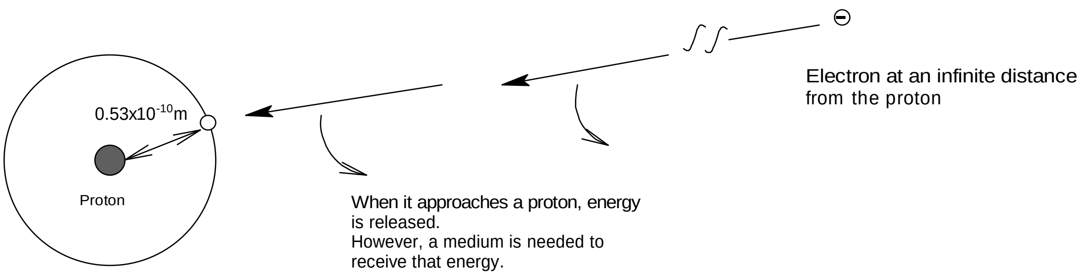

Figure 1. Electronic energy

[Electron energy is a negative value]

When a proton and an electron become a hydrogen atom, energy is released (if there is no medium to receive the released energy, this phenomenon does not occur, and the proton and electron are separated (plasma state). This can be seen in outer space where matter is thin). Since energy has been released, the electron's energy has a negative value.

For example, the average distance between the nucleus and electron of a hydrogen atom is about 0.53 Å. The potential energy (*V*) of a hydrogen atom is:

$$V = k\frac{Q_1Q_2}{r} = \frac{1}{4\times3.14\times8.85\times10^{-12}\mathrm{C}^2\cdot\mathrm{N}^{-1}\cdot\mathrm{m}^{-2}}\frac{-1.6\times10^{-19}C\times1.6\times10^{-19}\mathrm{C}}{0.53\times10^{-10}m}$$

$$= -4.35\times10^{-18}\mathrm{N}\cdot\mathrm{m}(\equiv \mathrm{J})$$

Converted to per mole, this is -2.62× 10^6 J or -2620 kJ, and the negative sign indicates that that amount of work was done (or energy was released) to the outside world (outside the hydrogen atom) (see **1170** for the meaning of the *k* value).

[Electronic energy]

When electrons condense near the nucleus, *V* decreases, but due to the uncertainty principle, the kinetic energy (*T*) of the electrons increases. The total energy (*E*) is *T* + *V*, and this value is electronic energy.