1250: Discontinuity in the energy values of atomic electrons

(The discontinuity in the energy of atomic orbitals comes from the wave nature of electrons)

Key words: quantization; standing waves; wave interference; half wavelength; quantum numbers; atomic orbitals

[Energy levels of hydrogen atoms]

The electron of a hydrogen atom is located at approximately 0.53 Å, and its energy is -1311 kJ/mol. There is no lower energy state. There are multiple states higher than this minimum energy, and the energy values are discrete, starting from the lowest at -328, -145, -82 (kJ/mol), and so on. This phenomenon is called energy being quantized.

[Electrons on atoms exist as standing waves]

Atoms do not change over time, so they are in a stationary state, and the electrons contained in atoms and molecules exist as standing waves. There are multiple standing waves, and each has its own unique energy and shape (the shape is expressed by a wave function (≡ atomic orbital)). This is a characteristic of a wave.

For example, when you blow into a flute (a musical instrument) with the resonating tube of a fixed length, the sound of a fixed wavelength is produced (a type of standing wave). When you blow harder, overtones are produced. They are also standing waves. Electrons inside atoms exist as three-dimensional standing waves, and the standing waves of atomic electrons correspond to atomic orbitals (waves with wavelengths that do not become standing waves cannot exist due to wave interference). The orbitals are named in order of decreasing energy as 1*s* atomic orbital, 2*s* atomic orbital, etc. (We will go into more detail later). In the case of a hydrogen atom, the energy (orbital energy) corresponding to the 1s atomic orbital is -1311kJ/mol, and that of the 2s is -328kJ/mol.

In short, since electrons are waves, the waves that can exist (standing waves) are 1, 2, 3, etc. (natural number multiples) of half the wavelength, and the energy corresponding to each is discrete values.

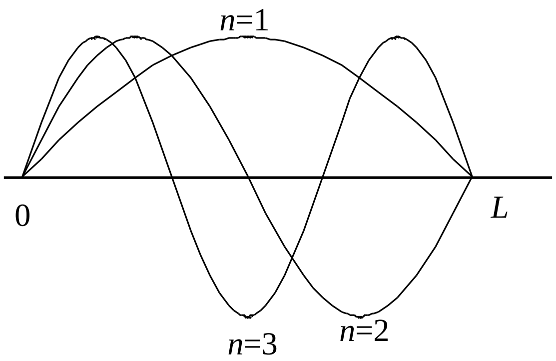

Figure 1. For a tube or string of length *L*, the reference tone is a standing wave with a wavelength of 2*L*. Waves whose pitch is twice, three times, etc. the reference tone are also standing waves. In quantum mechanics, the n that appears here is called the quantum number. Since this example is a one-dimensional wave function, there is only one quantum number (*n*) that controls its shape.