

1120: Uncertainty principle (uncertainty relation)

(The uncertainty principle is the most basic idea in quantum theory. Let's make sure we remember the relation here.)

Key words: Particle momentum; uncertainty of position; uncertainty of momentum; uncertainty relation, Heisenberg

The uncertainty principle is a principle of quantum mechanics that states that the position (x) of a particle (electron) and the momentum (p : momentum: mass (m) \times velocity (v)) of the particle cannot be determined accurately at the same time.

The uncertainty principle can be expressed mathematically as follows. Let the uncertainty of a particle's momentum be Δp , and the uncertainty of its position be Δx . The uncertainty principle is,

$$\Delta p \Delta x \geq \frac{\hbar}{2}$$

This is the relational equation. \hbar is Planck's constant (h) divided by 2π (i.e., 1.05457×10^{-34} Js). Since this is a relational equation, its official name is the uncertainty relationship.

The meaning of this equation is that if you try to determine the position of a particle accurately ($\Delta x \rightarrow 0$), the uncertainty of the momentum increases as $\Delta p \rightarrow \infty$. Conversely, if you try to determine the momentum accurately, the position of the particle cannot be determined (you don't know where it is).

Although it does not come up often in chemistry, the uncertainty relationship is the following relationship between time (t) and energy (E):

$$\Delta E \Delta t \geq \frac{\hbar}{2}$$

This can be easily derived from the uncertainty relation between position and momentum. The uncertainty relation is the most basic relation and the most important concept in quantum mechanics. This relation was discovered in 1927 by Heisenberg, W. K. (1901-1976, Germany).