1170: Supplementary information on the forces that make up atoms

(Only the four fundamental forces of nature, the Coulomb force, governs chemistry. Understand it mathematically.)

Key words: Electromagnetic force; dielectric constant of vacuum; relationship between Coulomb force between charges and distance

An electromagnetic force acts between electrons and atomic nuclei, preventing electrons from easily flying out of the nucleus. This electromagnetic force is also called the Coulomb force, or, when it is only electricity, the electrostatic force.

The magnitude (f) of the Coulomb force acting between two charges Q_1 and Q_2 separated by a distance r is expressed by the following equation:

$$f = k\frac{Q_1 Q_2}{r^2}$$

$$k = \frac{1}{4\pi\varepsilon_0} \qquad \varepsilon_0 = 8.8537\times10^{-12}\,\mathrm{C^2N^{-1}m^{-2}}$$

Here, ε_0 is a quantity called the dielectric constant of a vacuum but can be thought of as a constant to ensure consistency with the units of physical quantities. (In the cgs unit system, $k = 1$.) C, N, and m are units of charge, force, and distance, which are Coulomb, Newton, and meter, respectively.

The charge of an electron is negative, -1.6022×10^{-19}C, and that of a proton is positive, 1.6022×10^{-19}C, so the force acting between these particles 1 Å apart is approximately -2.3×10^{-8}N. Converting this to one mole, the standard in chemistry (multiplying by Avogadro's number (6.0221×10^{23})), gives approximately -1.4×10^{16}N (this value is enormous, as the force required to lift a 1kg object is 9.8N). As for the signs, negative forces indicate attractive forces, and positive forces indicate repulsive forces.