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Highly Exaggerated Representations of the Hydrogen Atom and Molecule in Elementary Textbooks of Physics and Chemistry

Pavle I. Premović
Laboratory for Geochemistry, Cosmochemistry and Astrochemistry,
University of Niš, P.O. Box 224, 18000 Niš, Serbia

In elementary physics and chemistry textbooks, we find the following (or similar) illustration of the Bohr model hydrogen atom at its ground state, Fig. 1. Proton (⊕) is shown at the center and the electron (⊖) is orbiting in the first Bohr orbit around the proton.

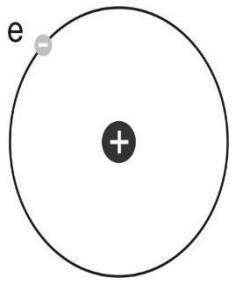

Fig. 1: Bohr model of the hydrogen atom.

The value of the radius of this orbit is a physical constant that is approximately equal to 5.3×10^{-11} m. The (charge) radius of the proton is about 0.85×10^{-15} m. Thus, the mean distance between electron and proton is equal to about 31000 proton diameters. In other words, the representation of the Bohr hydrogen atom model given in Fig. 1 (or similar) is highly exaggerated. As far as we are aware, this is not clearly emphasized in any of the textbooks mentioned above.

We encounter a similar problem in these textbooks when they talk about hydrogen molecule. This molecule is usually illustrated by the so-called Lewis (electron pair) structure as in Fig. 2 (or similar). This structure is based on Bohr's model of the hydrogen atom.

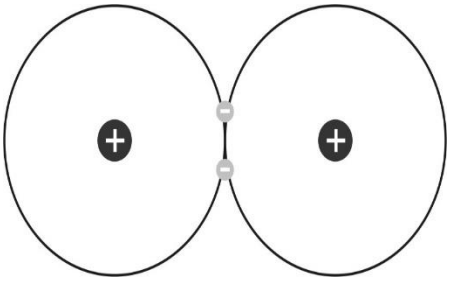

Fig. 2: Lewis structure of hydrogen molecule.

Each hydrogen atom in this molecule contains one electron and one proton. These atoms form a chemical (covalent) bond by sharing one electron each. The optimal internuclear distance between the two protons of the hydrogen molecule is named the bond distance (or length)**.** This distance is equal to about 7.4×10^{-11} m or about 43500 proton diameters apart. In other words, this or similar pictures of hydrogen molecules are also highly exaggerated. As far as we are aware, this is not explicitly indicated in elementary textbooks of physics and chemistry.

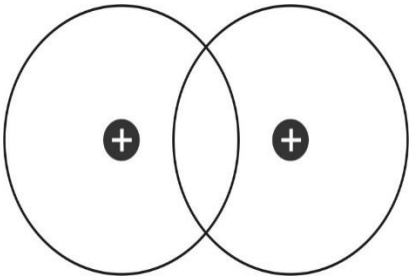

Fig. 3: Molecular orbital model of hydrogen molecule: overlapping 1s orbitals.

The molecular orbital approach is superior in describing the bond between two hydrogen atoms in the hydrogen molecule over the Lewis electron-pair approach. It is reasonable to say that the Lewis electron-pair bond in this molecule is equivalent to the molecular orbital description of a bonding molecular orbital occupied by a tightly paired of 1s electrons, Fig. 3. Thus, the exaggerated picture of the hydrogen molecule in textbooks of physics and chemistry, based on the theory of molecular orbitals, is similar to that of Lewis's picture in these books.

The above high exaggerations of the representations of the hydrogen atoms can be extended to other light and heavy atoms. For example, the nuclear diameter of cesium is about 1.2×10^{-14} m. The radius of the cesium atom where its valence 6s electron resides is roughly about 3.3×10^{-10} m. So, the distance between the cesium nucleus and its 6 s electron is about 28000 diameters.