

Correlation of Aqueous Redox Potentials with Gaseous Ionization Potentials: Influence of the Magnetic Momenta of Electron and Proton

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Water plays an important role in many terrestrial and atmospheric processes as a mediator of electron transfer between gaseous species. In a recent investigation of the relation between aqueous standard redox potentials and gaseous ionization potentials, simple linear dependences were discovered for every group of elements of the periodic table.¹ This linearity was then used to estimate the hitherto unknown ionization potentials of actinide elements from their aqueous polarographic half-wave potentials.²

However, in these correlations, the ionization potentials (which are generally negative as per theory; for example, the ionization potential of hydrogen is -13.56 eV) had to be taken as positive, as is usually done *without explanation* in electrochemistry.^{3,4} On investigating the reasons as to why the energy required to extract electrons from elements should be negative, the author found that the negative energy arises from Bohr's (or Schrodinger's) considerations of the energy of atoms. For example, in the case of hydrogen, they took the sum,

$$I = E_{\text{kin}} + E_{\text{coul}} = -13.56\text{eV}. \quad [1]$$

of the kinetic energy, $E_{\text{kin}} = (1/2)\mu_{\text{H}} v_{\text{H}}^2 = 13.56 \text{ eV}$, and coulombic energy $E_{\text{coul}} = -e^2/4\pi\epsilon_0 a_{\text{H}} = -2E_{\text{kin}} = -27.12 \text{ eV}$, where μ_{H} is the reduced mass of the atom, a_{H} is the Bohr radius, $v_{\text{H}} = e^2/4\pi\epsilon_0 p_{\omega} = e^2/2\epsilon_0 h$, is the linear velocity (is actually equal to the sum of the linear velocities of the electron and proton in the hydrogen atom) and p_{ω} is the angular momentum (is again the sum of the angular momenta of the electron and proton). Thus they obtained the value -13.56eV as the ionization energy (I).

The angular momenta of the electron and proton are in fact sustained by their magnetic momenta as per Larmor's relations. Thus Bohr and others forgot to take into account the magnetic energy due to the magnetic momentum of hydrogen ($\mu_{\text{mag,H}}$) arising from those of the electron and proton.⁵ The present author has calculated this magnetic energy using Larmor's relations and finds that it is equal to $E_{\text{mag}} = \mu_{\text{mag,H}} H_{\text{H}} = -E_{\text{coul}}$ where $H_{\text{H}} = -(2\mu_{\text{H}}\omega_{\text{H}}/e)$ is the magnetic field and ω_{H} is the angular velocity. This shows that the electron and proton are separated by the Bohr radius in a stable hydrogen atom due to the balance of the attractive coulombic and repulsive magnetic forces at this distance. Thus the ionization energy (I) of hydrogen is the sum of the energies,

$$I = E_{\text{kin}} + E_{\text{coul}} + E_{\text{mag}} = +13.56\text{eV} \quad [2]$$

This explains the experimental finding that 13.56 eV are "required" to ionize the hydrogen atom.

Amongst the other interesting results, it turns out that due to the electrical and magnetic properties of the electron and proton, the de Broglie waves associated with matter are in fact electromagnetic waves of velocity $v_{\text{dB}} = v_{\text{H}} = \alpha c$ where α is the fine structure constant and c is velocity of electromagnetic radiation in vacuum. Thus, α is the refractive index of electromagnetic radiation in passing through the atom. It is also the ratio of the Compton wavelength ($\lambda_{\text{C}} = h/\mu_{\text{H}}c$) to the de Broglie wavelength ($\lambda_{\text{dB}} = h/\mu_{\text{H}}v_{\text{dB}}$).

References

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