Chemical Potential from the Beginning

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The calculation of chemical reactions can begin *in medias res* with a definition of the chemical potential μ. The simplest way to introduce this quantity is to characterize it by a set of typical and easily observable properties, i.e. by designing a kind of "wanted poster" for μ. This phenomenological description may be supported by a direct measuring procedure, a method normally used for the quantification of basic concepts such as length, time or mass. The proposed approach is elementary, does not require any special previous knowledge, and immediately leads to results that can be utilised practically. It can be used at school starting with the first chemistry lessons [1]. To predict whether or not a considered reaction is possible is extremely simple if we use the chemical potential (figure 1). Moreover, the chemical potential is key in dealing with chemical problems. Starting from this central quantity, it is possible to explore many other fields [2, 3]. Its dependence upon temperature, pressure and concentration leads directly to construction of phase diagrams, deduction of the mass action law, calculation of equilibrium constants, solubilities, and many other data. An expansion of the concept to colligative phenomena, diffusion processes, surface effects, electrochemical processes, etc., is easily possible. Furthermore, the same tools allow us to solve problems even at the atomic and molecular level, that are usually treated by quantum statistical methods [4].

Modifications of substances are ubiquitous in households and the environment, in nature and in engineering. Selected simple and safe demonstration experiments strengthen our understanding of these processes and forge links with everyday experiences. In the presentation, some of the experiments will be shown live, some will be presented in short video films.

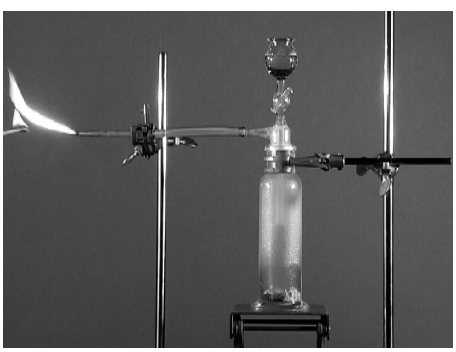

Figure 1. Demonstration experiment "carbide lamp": Calcium carbide reacts with water by forming the combustible gas ethyne (in spite of its high positive μ value) because the chemical potentials of the reactants together exceed those of the combined products:

$$\begin{array}{lcc} & CaC_2 + 2\,H_2O & \rightarrow Ca(OH)_2 + C_2H_2 \\ \mu^{\ominus}/\text{kJ}\cdot\text{mol}^{-1}: & \underbrace{(-68)\quad 2\cdot(-237)}_{-542} & > \quad \underbrace{(-898)\qquad (+209)}_{-689} \end{array}$$

References

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[4] G. Job, Proc. Taormina Conf. on Thermodynamics, Classe I di Scienze Fis. Mat. e Nat. Vol. LXX – Suppl. N. 1, 1992, 385-409.