Entropy Production and Chemical Reactions in Nonequilibrium Plasma

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Abstract

In this work, methods based upon nonequilibrium thermodynamics are elucidated to predict stationary states of chemical reactions in nonequilibrium plasma, and limits for energy conversion efficiency. Two example reactions are used: CO2 splitting and NH3 synthesis, with emphasis on CO2 splitting. Expectations from the theoretical framework are compared to experimental results for both reactions, and reasonable agreement is obtained. The conclusion is that the probability of observing either reactants or products increases with the amount of energy dissipated by that side of the reaction as heat through collisions with hot electrons. The side of the reaction that dissipates more energy as heat has a higher probability of occurrence. Furthermore, endergonic chemical reactions in nonequilibrium plasma, such as CO2 splitting at low temperature, require an intrinsic energy dissipation to satisfy the 2nd law of thermodynamics – a sufficient and necessary waste. This intrinsic dissipation limits the maximum theoretical energy conversion efficiency

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