A two-dimensional model of the resonant electron-molecule collision processes with one nuclear and one electronic degree of freedom introduced by Houfek, Rescigno and McCurdy [Phys. Rev. A **73**, 032721 (2006)] and a similar two-dimensional model of the dissociative recombination with potential proposed by Hamilton [Ph.D. thesis, University of Colorado, (2003)] are formulated within the time-dependent framework and solved numerically using the finite-element method with the discrete variable representation basis, the exterior complex scaling method and the generalized Crank-Nicolson method. On the model of electron-molecule collisions we illustrate how the time-dependent calculations can provide a deep insight into the origin of oscillatory structures in the vibrational excitation cross sections if one evaluates the cross sections not only at sufficiently large time to obtain the final cross sections, but rather at several characteristic times which are given by the evolution of the system. With use of the time-dependent calculations we demonstrate the complex nature of the dissociative recombination model dynamics and we propose the interpretation of the recombination process mechanism. We also propose few techniques for the explanation of the sharp structures in the dissociative recombination cross sections and we study the populations of the its final states for the first time in theoretical calculations. Numerical results are presented for N_2-like, NO-like, and F_2-like models of the electron-molecule collisions and H_2^+-like model of the dissociative recombination. The results are compared with ones obtained within time-independent approach and in the electron-molecule case also within the local complex potential approximation.