3.9 Condensation Processes in High Temperature Clouds

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Neither thermodynamic calculations nor standard nucleation theory describe condensation processes in cosmic clouds, but rather are a first approximation. Condensation is an irreversible kinetic, not equilibrium, process. The nominal molecules of condensed minerals (e.g. Al_2O_3, $CaTiO_3$, $MgAl_2O_4$) occur only in the bulk lattice not in cosmic gases. Reactions among gas molecules must be an intrinsic part of condensation. Molecules yielding a particular condensate are a small fraction, less than 10^{-3}, of condensible and reactive (e.g. H, H_2, H_2O) molecules. No theoretical or experimental results are available for condensation under such conditions. There is no basis for expecting nearly pure, known minerals to form in cosmic clouds. A generalization of nucleation theory following Hirschfelder (JCP, 61, 2690, 1974) can be made, in principle. No thermodynamic data is known for most of the possible compositions of nucleating clusters and no calculations are possible. Grain compositions should fall between thermodynamic and kinetic calculations. An experimental study appears feasible and is planned. The following conclusions are drawn from the theoretical analysis. (1) An interpretation of interstellar grains may not be made using only terrestrial minerals. (2) Condensation temperatures and compositions of interstellar grains or primordial solar system condensates may not be deduced from equilibrium calculations.

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