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Volatile Element Chemistry in the Solar Nebula - Revisited 40 Years Later

Content :

The relative abundances of volatile to refractory elements are easily affected by condensation and evaporation and therefore thermochemical equilibrium calculations are important to quantitatively evaluate fractionations between gases and solids in astronomical environments. Fegley and Lewis (1980 Icarus) computed condensation temperatures for P, F, Cl, Na, and K in the solar nebula using Cameron (1973) solar abundances. They also calculated chemical equilibrium abundances of gases and solids as a function of pressure and temperature. Lodders (2003 ApJ) and Schaefer & Fegley (2010 in Principles and Perspectives in Cosmochemistry, Springer) updated this work as new thermodynamic data (e.g., Lodders 1999,2004 J Phys Chem Ref Data) and better solar abundances became available. Several recent advances in the past decade led us to revisit and extend our earlier work, e.g., (1) new thermodynamic data on halogen-bearing and phosphorus-bearing minerals, (2) new chemical analyses and mineralogical studies of halogens and their host phases in terrestrial and extraterrestrial samples, and (3) renewed interest in the 36Cl-36S and 129I-129Xe systems. The results of our chemical equilibrium calculations confirm those of Schaefer and Fegley (2010) for fluorine and chlorine. At complete chemical equilibrium (0.0001 bar total P) fluorine condenses at about 713 K (50 percent) and chlorine condenses at about 400 K (50 percent). Our results for bromine and iodine also revise our earlier work (Fegley and Lewis 1980, Lodders 2003) due to newer thermodynamic data for their host phases. Finally we also show how kinetic inhibition of condensate formation in the solar nebula (e.g., see Fegley 1988 LPI Tech Report 88-04) affects halogen condensation temperatures. This work was supported by grant NSF-AST 1517541 from the NSF Astronomy Program.

Summary :

We present condensation calculations for alkalis, halogens, and phosphorus that are based on the latest available thermodynamic data and solar elemental abundances. Our results confirm our earlier work (Schaefer & Fegley 2010) for chlorine and fluorine and update our earlier work (Fegley & Lewis 1980, Lodders 2003) for bromine and iodine. We also show how the kinetic inhibition of condensate formation affects halogen condensation temperatures.

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Comments :

Halogen condensation is important for understanding the 36Cl-36S and 129I-129Xe systems, the origin of chondritic material in meteorites and IDPs, and the origin of volatile-bearing presolar grains.