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Chemistry Under Extreme Conditions

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It has long been recognized that shock compression of condensed matter can generate chemical reactions. The best-known examples of this are the reactions that release energy during the detonation of a high explosive. Despite this, very little is known about molecular processes occurring behind the shock front in a condensed phase. I will describe a domain of "extreme chemistry" that is of particular interest and relevance. Extreme chemistry occurs when temperatures are comparable to molecular bond energies, and when molecular bond energies are strongly modified by pressure. In this region the notions of conventional chemistry must be completely rethought. I will review extreme chemistry in several contexts: the reactions of shocked liquids and plastics, reactions of detonating high explosives, and reactions under static compression. In the area of shocked liquids and plastics, I will ask whether traditional shock Hugoniot measurements can provide any information on underlying chemistry. For high explosives, I will discuss the nature of reactions at the Chapman-Jouget state. Finally, I will discuss the discovery of a novel superionic phase of water and a symmetric hydrogen bonded phase of formic acid under static compression. This work was performed under the auspices of the U.S. Department of Energy by University of California, Lawrence Livermore National Laboratory under Contract W-7405-Eng-48.