Understanding how individual atoms and molecules respond to irradiation by intense X-ray free-electron laser (XFEL) pulses is crucial for numerous applications of XFEL radiation, such as imaging of single (bio-)particles and nanocrystals, or the study of matter under extreme conditions. We have therefore extended our previous investigations of the multiphoton ionization of heavy atoms, such as Kr and Xe [1], and of high-\(Z\) atom containing molecules [2] from the soft into the hard X-ray range and to higher peak fluences than in previous studies. Using the 100-nm focus environment of the CXI end-station at the LCLS XFEL facility, we were able to reach peak intensities up to \(10^{19}\) W/cm\(^2\) at photon energies between 5 to 9 keV. This allowed us to study atomic and molecular ionization processes under unprecedented X-ray intensities and, in particular, under the identical conditions where typical coherent diffractive imaging experiments are performed. The results are thus important benchmarks for calculating radiation damage effects in FEL-based X-ray imaging experiments. In molecules, we observe a significant enhancement of the degree of ionization as compared to the equivalent, individual atoms and trace this effect to ultrafast charge transfer from the neighboring atoms in the molecule [3]. The comparison to new calculations, which are able to quantitatively reproduce the experimental data at all photon energies and intensities, also highlights the role of resonant and relativistic effects in the X-ray multiphoton ionization of heavy atoms [4].