Cation ordering in transition-metal oxides often drastically modifies their properties. We focus on A-and-B-site-ordered quadruple perovskite-structure oxides AA’₃B₂B’₂O₁₂, in which transition-metal ions are included at the A’, B, and B’ sites in an ordered manner. In such compounds A’-A’, A’-B, A’-B’, and B-B’ interactions compete with each other and play important role in giving rise to unusual properties. The A-and-B-site-ordered quadruple perovskite CaCu₃Fe₂Sb₂O₁₂ with magnetic Fe³⁺ at the B site and nonmagnetic Sb⁵⁺ at the B’ site was successfully synthesized under a high-pressure and high-temperature condition. The B-site Fe³⁺ spin sublattice adapts a tetrahedral framework and the Fe³⁺-Fe³⁺ antiferromagnetic interaction causes geometrical spin frustration as seen in the double perovskite Ca₂FeSbO₆. With the introduction of Cu²⁺ into the A’ site, the frustration is relieved by strong antiferromagnetic A’(Cu²⁺)-B(Fe³⁺) interaction, leading to a ferrimagnetic ordering below 160 K. When B’-site Sb⁵⁺ was replaced with Re⁵⁺, another A-and-B-site-ordered quadruple perovskite CaCu₃Fe₂Re₂O₁₂ was synthesized by a high-pressure technique. The compound contains magnetic Fe³⁺ at the B site and Re⁵⁺ at the B’ sites, and strong antiferromagnetic A’(Cu²⁺)-B'(Re⁵⁺) interaction overcomes the A'(Cu²⁺)-B(Fe³⁺) interaction, leading to a ferrimagnetism with the ferromagnetic A'(Cu²⁺)-B(Fe³⁺) spin arrangement below 550 K. More importantly, the electronic structure of CaCu₃Fe₂Re₂O₁₂ is half metallic and the compound shows large magnetoresistance by the spin-dependent transport.

Keywords: Perovskite-structure oxides, Magnetic interactions, Half metal