

41. Sample Problem 42-6 gives the fraction of silicon atoms that must be replaced by phosphorus atoms. We find the number the silicon atoms in 1.0 g, then the number that must be replaced, and finally the mass of the replacement phosphorus atoms. The molar mass of silicon is 28.086 g/mol, so the mass of one silicon atom is $(28.086 \text{ g/mol}) / (6.022 \times 10^{23} \text{ mol}^{-1}) = 4.66 \times 10^{-23} \text{ g}$ and the number of atoms in 1.0 g is $(1.0 \text{ g}) / (4.66 \times 10^{-23} \text{ g}) = 2.14 \times 10^{22}$. According to Sample Problem 42-6 one of every 5×10^6 silicon atoms is replaced with a phosphorus atom. This means there will be $(2.14 \times 10^{22}) / (5 \times 10^6) = 4.29 \times 10^{15}$ phosphorus atoms in 1.0 g of silicon. The molar mass of phosphorus is 30.9758 g/mol so the mass of a phosphorus atom is $(30.9758 \text{ g/mol}) / (6.022 \times 10^{23} \text{ mol}^{-1}) = 5.14 \times 10^{-23} \text{ g}$. The mass of phosphorus that must be added to 1.0 g of silicon is $(4.29 \times 10^{15})(5.14 \times 10^{-23} \text{ g}) = 2.2 \times 10^{-7} \text{ g}$.