

15.22 This problem asks that we compute the fraction of possible crosslink sites in 15 kg of polychloroprene when 5.2 kg of S is added, assuming that, on the average, 5.5 sulfur atoms participate in each crosslink bond. Given the butadiene repeat unit in Table 14.5, we may calculate its molecular weight as follows:

$$\begin{aligned} A(\text{chloroprene}) &= 4(A_{\text{C}}) + 5(A_{\text{H}}) + A_{\text{Cl}} \\ &= (4)(12.01 \text{ g/mol}) + 5(1.008 \text{ g/mol}) + 35.45 \text{ g/mol} = 88.53 \text{ g/mol} \end{aligned}$$

Which means that in 15 kg of chloroprene there are $\frac{15,000 \text{ g}}{88.53 \text{ g/mol}} = 169.4 \text{ mol} = n_{\text{chloro}}$.

For the vulcanization of polychloroprene, there are two possible crosslink sites per repeat unit—one for each of the two carbon atoms that are doubly bonded. Furthermore, each of these crosslinks forms a bridge between two repeat units. Therefore, we can say that there is the equivalent of one crosslink per repeat unit. Let us now calculate the number of moles of sulfur (n_{sulfur}) that react with the chloroprene, by taking the mole ratio of sulfur to chloroprene, and then dividing this ratio by 5.5 atoms per crosslink; this yields the fraction of possible sites that are crosslinked. Thus

$$n_{\text{sulfur}} = \frac{5200 \text{ g}}{32.06 \text{ g/mol}} = 162.2 \text{ mol}$$

And

$$\text{fraction sites crosslinked} = \frac{\frac{n_{\text{sulfur}}}{5.5}}{\frac{n_{\text{chloro}}}{5.5}} = \frac{162.2 \text{ mol}}{169.4 \text{ mol}} = 0.174$$