

15.37 (a) This problem asks that we determine how much ethylene glycol must be added to 20.0 kg of terephthalic acid to produce a linear chain structure of poly(ethylene terephthalate) according to Equation 15.9. Since the chemical formulas are provided in this equation we may calculate the molecular weights of each of these materials as follows:

$$\begin{aligned} MW(\text{ethylene glycol}) &= 2(A_{\text{C}}) + 6(A_{\text{H}}) + 2(A_{\text{O}}) \\ &= 2(12.01 \text{ g/mol}) + 6(1.008 \text{ g/mol}) + 2(16.00 \text{ g/mol}) = 62.07 \text{ g/mol} \end{aligned}$$

$$\begin{aligned} MW(\text{terephthalic acid}) &= 8(A_{\text{C}}) + 6(A_{\text{H}}) + 4(A_{\text{O}}) \\ &= 8(12.01 \text{ g/mol}) + 6(1.008 \text{ g/mol}) + 4(16.00 \text{ g/mol}) = 166.13 \text{ g/mol} \end{aligned}$$

The 20.0 kg mass of terephthalic acid equals 20,000 g or  $\frac{20,000 \text{ g}}{166.13 \text{ g/mol}} = 120.39 \text{ mol}$ . Since, according to

Equation 15.9, each mole of terephthalic acid used requires one mole of ethylene glycol, which is equivalent to  $(120.39 \text{ mol})(62.07 \text{ g/mol}) = 7473 \text{ g} = 7.473 \text{ kg}$ .

(b) Now we are asked for the mass of the resulting polymer. Inasmuch as one mole of water is given off for every repeat unit produced, this corresponds to 120.39 moles or  $(120.39 \text{ mol})(18.02 \text{ g/mol}) = 2169 \text{ g}$  or 2.169 kg since the molecular weight of water is 18.02 g/mol. The mass of poly(ethylene terephthalate) is just the sum of the masses of the two reactant materials [as computed in part (a)] minus the mass of water released, or

$$\text{mass [poly(ethylene terephthalate)]} = 20.0 \text{ kg} + 7.473 \text{ kg} - 2.169 \text{ kg} = 25.304 \text{ kg}$$