In-Class Exercise
Kevlar Synthesis
SOLUTIONS

Kevlar® is used in the core of skis. Calculate the mass of 1,4-phenylenediamine and terephthaloyl chloride required for the synthesis of 1-kg of Kevlar®. Also determine the moles of HCl that will be produced during this synthesis.

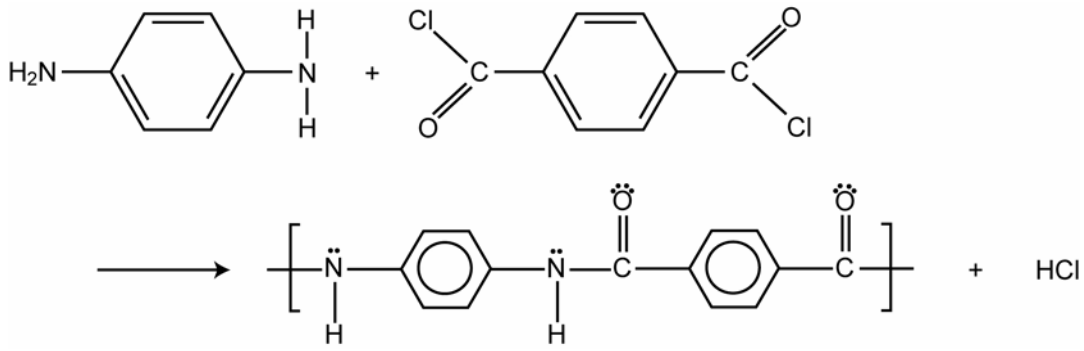

Figure 1. Synthesis of Kevlar® from 1,4-phenylenediamine and terephthaloyl chloride.

First, we must calculate the molecular weight of 1,4-phenylenediamine, terephthaloyl chloride, and Kevlar®. The atomic weights of the elements are from http://www.webelements.com.

For 1,4-phenylenediamine:

$A_{1,4\text{-phenylenediamine}} = 8A_H + 2A_N + 6A_C =$
$= 8\ (1.00794\ g/mol) + 2\ (14.0067\ g/mol) + 6\ (12.0107\ g/mol) = 108.141\ g/mol$

For terephthaloyl chloride:

$A_{\text{terephthaloyl chloride}} = 2A_{Cl} + 2A_O + 8A_C + 4A_H =$
$= 2\ (35.453\ g/mol) + 2\ (15.9994\ g/mol) + 8\ (12.0107\ g/mol) + 4\ (1.00794\ g/mol) =$
$= 203.02\ g/mol$

For Kevlar®:

$A_{Kevlar®} = 2A_N + 10A_H + 2A_O + 14A_C =$
$= 2\ (14.0067\ g/mol) + 10\ (1.00794\ g/mol) + 2\ (15.9994\ g/mol) +$
$+ 14\ (12.0107\ g/mol) = 238.241\ g/mol$

Now, we must calculate the number of moles of Kevlar® that we would like to prepare:

$$n_{Kevlar®} = \frac{m_{Kevlar®}}{A_{Kevlar®}} = \frac{1000.\cdot g}{238.241\cdot g/mol} = 4.197\cdot mol$$

We can see from the chemical reaction, that for every mole of Kevlar®, we need one mole of 1,4-phenylenediamine and one mole of terephthaloyl chloride. Hence, the mass of each of the reactants is:

$m_{1,4\text{-phenylenediamine}} = n_{1,4\text{-phenylenediamine}} \bullet A_{1,4\text{-phenylenediamine}} =$
$= 4.197 \text{ mol} \bullet 108.141 \text{ g/mol} = 453.9 \text{ g}$

$m_{\text{terephthaloyl chloride}} = n_{\text{terephthaloyl chloride}} \bullet A_{\text{terephthaloyl chloride}} = 4.197 \text{ mol} \bullet 203.02 \text{ g/mol} = 852.1 \text{ g}$

The moles of HCl that will be produced is twice the number of moles of Kevlar® that will be produced during the reaction, namely 8.4 mol.