A high school student wants to design a bottle rocket that produces 50 L of CO_2. Given that the densities of $NaHCO_3$ and CH_3CH_2OOH are 2.2 and 1.05 gm/cm^3, what volume is needed for the fuel compartment?

Solution: Step 1. calculate the number of moles of CO_2 to be produced.

$$n = \frac{PV}{RT} = \frac{(1\,atm)(50\,L)}{\left(0.08206\,\frac{Latm}{molK}\right)(298\,K)} = 2\,moles$$

Step 2. Determine the masses of the reactants.

$$m_{NaHCO_3} = nM_m = (2\,mol)\left(84\,\frac{gm}{mol}\right) = 168\,gm$$

$$m_{CH_3CH_2COOH} = nM_m = (2\,mol)\left(60\,\frac{gm}{mol}\right) = 120\,gm$$

What volume is needed for the fuel compartment?

Solution: Step 3. Calculate the volume of each reactant. We use the density of each reactant.

$$V_{NaHCO_3} = \frac{m}{\rho} = \frac{168\ gm}{2.2\ gm/cm^3} = 76.4\ cm^3$$

$$V_{CH_3CH_2COOH} = \frac{m}{\rho} = \frac{120\ gm}{1.05\ gm/cm^3} = 114.3\ cm^3$$

The sum is $V_{total} = 190.7\ cm^3$.