Using Stochiometry in Simple Chemistry Experiments

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Practical Problem: It was decided to inflate a common latex balloon to 5cm radius by the hydrogen gas produced during a single-displacement reaction: $2\,\mathrm{HCl(aq)} + \mathrm{Zn(s)} \longrightarrow \mathrm{ZnCl_2(s)} + \mathrm{H_2(g)}$ that uses an $N/10$ i.e. 0.1M HCl solution (available in many drugstores, typically in 200ml bottles). How much reactants are needed?

Solution: We need to inflate the balloon to about 5cm radius. Assuming the balloon to be a sphere gives us the volume of balloon, V_b, as: $V_b = \frac{4}{3} \cdot \pi r^3 \mathrm{cm}^3 = 523.599 \mathrm{cm}^3$.

Assuming the density of hydrogen[1] at STP as $0.0000899\mathrm{g\,cm^{-3}}$, the mass of hydrogen is $523.599 \times 0.0000899\mathrm{g} = 0.0471\mathrm{g}$. Since 1mol of $\mathrm{H_2(g)}$ has a mass of $2 \times 1.008\mathrm{g} = 2.016\mathrm{g}$, we need $\frac{0.0471}{2.016}\mathrm{mol} = 0.0233\mathrm{mol}$ $\mathrm{H_2(g)}$.

Balancing the reaction, $2\,\mathrm{HCl(aq)} + \mathrm{Zn(s)} \longrightarrow \mathrm{ZnCl_2(s)} + \mathrm{H_2(g)}$, we see that to produce 1 mol $\mathrm{H_2(g)}$ we need 2mol $\mathrm{HCl(aq)}$ and 1mol $\mathrm{Zn(s)}$.

This means that to produce $0.0233\mathrm{mol}$ $\mathrm{H_2(g)}$ we need $2 \times 0.0233\mathrm{mol} = 0.0466\mathrm{mol}$ $\mathrm{HCl(aq)}$. We have a 0.1M HCl (aqueous) solution which means that $\frac{\text{mol of solute}}{\text{litres of solution}} = 0.1$. Clearly, we need $\frac{0.0466}{0.1} = 0.466\mathrm{L}$ or **466**ml **HCl**.

The amount of zinc needed $= 0.0233 \times$ molar mass of zinc$= 0.0233 \times 65.45\mathrm{g} =$ **1.525**g.

[1] See https://ptable.com/#Properties/Weight

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