A limiting reactant problem

Sodium phosphate reacts with calcium nitrate in the reaction below.

$$2Na_3PO_4(aq) + 3Ca(NO_3)_2(aq) \rightarrow Ca_3(PO_4)_2(s) + 6NaNO_3(aq)$$

If you start with 250.g of each reactant in the reaction above, how much $Ca_3(PO_4)_2$ can you prepare?

Answer and solution

- You can prepare **158** g $Ca_3(PO_4)_2$.

First, find formula weights of the compounds of interest:

Na_3PO_4	163.94 g/mol
$Ca(NO_3)_2$	164.10 g/mol
$Ca_3(PO_4)_2$	310.18 g/mol

This is a limiting reactant problem, since we were given amounts of more than one reactant. To solve it, find the amount of $Ca_3(PO_4)_2$ that could be produced from each reactant.

$$250\text{g Na}_3\text{PO}_4 \times \frac{\text{mol}}{163.94\,\text{g}} \times \frac{1\,\text{mol Ca}_3(\text{PO}_4)_2}{2\,\text{mol Na}_3\text{PO}_4} \times \frac{310.18\,\text{g}}{\text{mol}} = 237\,\text{g Ca}_3(\text{PO}_4)_2$$

$$250\text{g Ca}(\text{NO}_3)_2 \times \frac{\text{mol}}{164.10\,\text{g}} \times \frac{1\,\text{mol Ca}_3(\text{PO}_4)_2}{3\,\text{mol Ca}(\text{NO}_3)_2} \times \frac{310.18\,\text{g}}{\text{mol}} = 158\,\text{g Ca}_3(\text{PO}_4)_2$$

Since the reaction stops when we run out of one reactant, we can only produce 158g of product. Calcium nitrate is the limiting reactant.

A simple stoichiometry problem

Ammonia (NH_3) can be made from this reaction.

$$N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$$

How much hydrogen gas do you need to produce 250.g of NH_3?

Answer and solution

- You need **44.5** g H_2.

Formula weights:

NH_3	17.03 g/mol
H_2	2.02 g/mol

This is a simple 3-step stoichiometry problem. Solve with dimensional analysis.

$$250\,\text{g NH}_3 \times \frac{\text{mol}}{17.03\,\text{g}} \times \frac{3\,\text{mol H}_2}{2\,\text{mol NH}_3} \times \frac{2.02\,\text{g}}{\text{mol}} = 44.5\,\text{g H}_2$$

Percent yield problem

Sodium and water react violently to produce sodium hydroxide and hydrogen gas.

$$2Na(s) + 2H_2O(l) \rightarrow 2NaOH(aq) + H_2(g)$$

If you start with 250.g Na metal and produce 375g NaOH, what is the percent yield of the reaction?

Answer and solution

- The percent yield is **86.2** %.

Formula weights:

Na	22.99 g/mol
NaOH	40.00 g/mol

First, find the theoretical yield using dimensional analysis.

$$250\,\text{g Na} \times \frac{\text{mol}}{22.99\,\text{g}} \times \frac{2\,\text{mol NaOH}}{2\,\text{mol Na}} \times \frac{40.00\,\text{g}}{\text{mol}} = 435\,\text{g NaOH}$$

Then, calculate the percent yield.

$$\frac{375\,\text{g}}{435\,\text{g}} \times 100\,\% = 86.2\,\%$$