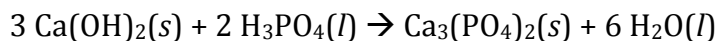


Limiting Reagent

Exercise 20

What is the theoretical yield of $\text{Ca}_3(\text{PO}_4)_2(\text{s})$ by the reaction



when 10.00 g $\text{Ca}(\text{OH})_2$ and 10.00 g H_3PO_4 are mixed? [F.W. $\text{Ca}(\text{OH})_2 = 74.10 \text{ u}$; M.W. $\text{H}_3\text{PO}_4 = 97.99 \text{ u}$; F.W. $\text{Ca}_3(\text{PO}_4)_2 = 310.18 \text{ u}$]

Answer:

$$\text{mol Ca}(\text{OH})_2: 10.00 \text{ g Ca}(\text{OH})_2 \times \frac{1 \text{ mol Ca}(\text{OH})_2}{74.10 \text{ g Ca}(\text{OH})_2} = 0.13495 \text{ mol Ca}(\text{OH})_2$$

$$\text{mol H}_3\text{PO}_4: 10.00 \text{ g H}_3\text{PO}_4 \times \frac{1 \text{ mol H}_3\text{PO}_4}{97.99 \text{ g H}_3\text{PO}_4} = 0.10205 \text{ mol H}_3\text{PO}_4$$

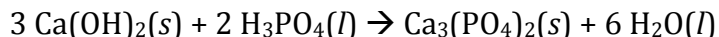
Identify limiting reagent by dividing each number of moles by its stoichiometric coefficient in the balanced equation to determine the "sets" for each:	Or
$\begin{aligned} \text{sets Ca}(\text{OH})_2: & 0.13495 \text{ mol Ca}(\text{OH})_2 \\ & \times \frac{1 \text{ set Ca}(\text{OH})_2}{3 \text{ mol Ca}(\text{OH})_2} \\ & = 4.498425 \text{E} \\ & - 2 \text{ mol Ca}(\text{OH})_2 \end{aligned}$	$0.13495 \text{ mol of Ca}(\text{OH})_2 \times \frac{2 \text{ mol of H}_3\text{PO}_4}{3 \text{ mol of Ca}(\text{OH})_2}$
$\begin{aligned} \text{sets H}_3\text{PO}_4 & \\ = & 0.1020512297173181 \text{ mol H}_3\text{PO}_4 \\ \times \frac{1 \text{ set H}_3\text{PO}_4}{2 \text{ mol H}_3\text{PO}_4} & = 0.051025 \text{ mol H}_3\text{PO}_4 \end{aligned}$	$= 0.0899 \text{ mol H}_3\text{PO}_4$
	Since we have more than that much of H_3PO_4 $\text{Ca}(\text{OH})_2$ is limiting

→ $\text{Ca}(\text{OH})_2$ is the limiting reagent, has fewer "sets"

Calculate the mass of $\text{Ca}_3(\text{PO}_4)_2$:

$$\begin{aligned} \text{mass Ca}_3(\text{PO}_4)_2 & \\ = 0.13495 \text{ mol Ca}(\text{OH})_2 & \times \frac{1 \text{ mol Ca}_3(\text{PO}_4)_2}{3 \text{ mol Ca}(\text{OH})_2} \times \frac{310.18 \text{ g Ca}_3(\text{PO}_4)_2}{1 \text{ mol Ca}_3(\text{PO}_4)_2} \\ & = 13.95321 = 13.95 \text{ g Ca}_3(\text{PO}_4)_2 \end{aligned}$$

What is the theoretical yield of $\text{Ca}_3(\text{PO}_4)_2(\text{s})$ by the reaction



when 8.00 g $\text{Ca}(\text{OH})_2$ and 11.00 g H_3PO_4 are mixed? [F.W. $\text{Ca}(\text{OH})_2 = 74.10 \text{ u}$; M.W. $\text{H}_3\text{PO}_4 = 97.99 \text{ u}$; F.W. $\text{Ca}_3(\text{PO}_4)_2 = 310.18 \text{ u}$]

Answer

$$\text{mol Ca}(\text{OH})_2: 8.00\text{g Ca}(\text{OH})_2 \times \frac{1 \text{ mol Ca}(\text{OH})_2}{74.10\text{g Ca}(\text{OH})_2} = 0.107962 \text{ mol Ca}(\text{OH})_2$$

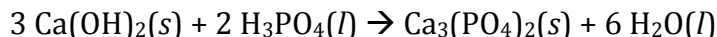
$$\text{mol H}_3\text{PO}_4: 11.00\text{g H}_3\text{PO}_4 \times \frac{1 \text{ mol H}_3\text{PO}_4}{97.99\text{g H}_3\text{PO}_4} = 0.112256 \text{ mol H}_3\text{PO}_4$$

<p>Identify limiting reagent by dividing each number of moles by its stoichiometric coefficient in the balanced equation to determine the “sets” for each:</p> <p><i>sets Ca(OH)₂</i>: $0.107962213 \text{ mol Ca}(\text{OH})_2 \times \frac{1 \text{ set Ca}(\text{OH})_2}{3 \text{ mol Ca}(\text{OH})_2} = 0.0359874 \text{ mol Ca}(\text{OH})_2$</p> <p><i>sets H₃PO₄</i> = $0.11225 \text{ mol H}_3\text{PO}_4 \times \frac{1 \text{ set H}_3\text{PO}_4}{2 \text{ mol H}_3\text{PO}_4} = 5.612817 \text{ E} - 2 \text{ mol H}_3\text{PO}_4$</p> <p>→ $\text{Ca}(\text{OH})_2$ is the limiting reagent, has fewer “sets”</p>	<p>Or</p> <p>$0.107962 \text{ mol of Ca}(\text{OH})_2 \times \frac{2 \text{ mol of H}_3\text{PO}_4}{3 \text{ mol of Ca}(\text{OH})_2}$</p> <p>= <u>0.071974</u> mol H_3PO_4</p> <p>Since we have more than that much of H_3PO_4 $\text{Ca}(\text{OH})_2$ is limiting</p>
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Calculate the mass of $\text{Ca}_3(\text{PO}_4)_2$:

$$\begin{aligned} \text{mass Ca}_3(\text{PO}_4)_2 &= 0.107962 \text{ mol Ca}(\text{OH})_2 \times \frac{1 \text{ mol Ca}_3(\text{PO}_4)_2}{3 \text{ mol Ca}(\text{OH})_2} \times \frac{310.18\text{g Ca}_3(\text{PO}_4)_2}{1 \text{ mol Ca}_3(\text{PO}_4)_2} \\ &= 11.162573 = 11.2\text{g Ca}_3(\text{PO}_4)_2 \end{aligned}$$

What is the theoretical yield of $\text{Ca}_3(\text{PO}_4)_2(\text{s})$ by the reaction



when 12.00 g $\text{Ca}(\text{OH})_2$ and 12.00 g H_3PO_4 are mixed? [F.W. $\text{Ca}(\text{OH})_2 = 74.10 \text{ u}$; M.W. $\text{H}_3\text{PO}_4 = 97.99 \text{ u}$; F.W. $\text{Ca}_3(\text{PO}_4)_2 = 310.18 \text{ u}$]

Answer:

$$\text{mol Ca}(\text{OH})_2: 12.00 \text{ g Ca}(\text{OH})_2 \times \frac{1 \text{ mol Ca}(\text{OH})_2}{74.10 \text{ g Ca}(\text{OH})_2} = 0.161943 \text{ mol Ca}(\text{OH})_2$$

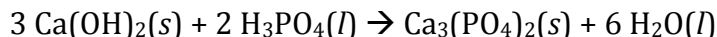
$$\text{mol H}_3\text{PO}_4: 12.00 \text{ g H}_3\text{PO}_4 \times \frac{1 \text{ mol H}_3\text{PO}_4}{97.99 \text{ g H}_3\text{PO}_4} = 0.122461 \text{ mol H}_3\text{PO}_4$$

<p>Identify limiting reagent by dividing each number of moles by its stoichiometric coefficient in the balanced equation to determine the "sets" for each:</p> <p><i>sets Ca(OH)₂</i>: $0.161943 \text{ mol Ca}(\text{OH})_2 \times \frac{1 \text{ set Ca}(\text{OH})_2}{3 \text{ mol Ca}(\text{OH})_2} = 5.39811\text{E} - 2 \text{ mol Ca}(\text{OH})_2$</p> <p><i>sets H₃PO₄</i>: $0.122461 \text{ mol H}_3\text{PO}_4 \times \frac{1 \text{ set H}_3\text{PO}_4}{2 \text{ mol H}_3\text{PO}_4} = 6.12307 \text{ E} - 2 \text{ mol H}_3\text{PO}_4$</p> <p>→ $\text{Ca}(\text{OH})_2$ is the limiting reagent, has fewer "sets"</p>	<p>Or</p> <p>$\frac{0.161943 \text{ mol of Ca}(\text{OH})_2 \times \frac{2 \text{ mol of H}_3\text{PO}_4}{3 \text{ mol of Ca}(\text{OH})_2}}{1} = 0.107933 \text{ mol H}_3\text{PO}_4$</p> <p>Since we have more than that much of H_3PO_4 $\text{Ca}(\text{OH})_2$ is limiting</p>	
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Calculate the mass of $\text{Ca}_3(\text{PO}_4)_2$:

$$\begin{aligned} \text{mass Ca}_3(\text{PO}_4)_2 &= 0.161943 \text{ mol Ca}(\text{OH})_2 \times \frac{1 \text{ mol Ca}_3(\text{PO}_4)_2}{3 \text{ mol Ca}(\text{OH})_2} \times \frac{310.18 \text{ g Ca}_3(\text{PO}_4)_2}{1 \text{ mol Ca}_3(\text{PO}_4)_2} \\ &= 16.74385 = 16.74 \text{ g Ca}_3(\text{PO}_4)_2 \end{aligned}$$

What is the theoretical yield of $\text{Ca}_3(\text{PO}_4)_2(\text{s})$ by the reaction



when 15.00 g $\text{Ca}(\text{OH})_2$ and 14.00 g H_3PO_4 are mixed? [F.W. $\text{Ca}(\text{OH})_2 = 74.10 \text{ u}$; M.W. $\text{H}_3\text{PO}_4 = 97.99 \text{ u}$; F.W. $\text{Ca}_3(\text{PO}_4)_2 = 310.18 \text{ u}$]

Answer:

$$\text{mol Ca}(\text{OH})_2: 15.00 \text{ g Ca}(\text{OH})_2 \times \frac{1 \text{ mol Ca}(\text{OH})_2}{74.10 \text{ g Ca}(\text{OH})_2} = 0.20242 \text{ mol Ca}(\text{OH})_2$$

$$\text{mol H}_3\text{PO}_4: 14.00 \text{ g H}_3\text{PO}_4 \times \frac{1 \text{ mol H}_3\text{PO}_4}{97.99 \text{ g H}_3\text{PO}_4} = 0.142871 \text{ mol H}_3\text{PO}_4$$

Identify limiting reagent by dividing each number of moles by its stoichiometric coefficient in the balanced equation to determine the "sets" for each:

$$\begin{aligned} \text{sets Ca}(\text{OH})_2: & 0.202429 \text{ mol Ca}(\text{OH})_2 \\ & \times \frac{1 \text{ set Ca}(\text{OH})_2}{3 \text{ mol Ca}(\text{OH})_2} \\ & = 6.74763\text{E} \\ & - 2 \text{ mol Ca}(\text{OH})_2 \end{aligned}$$

$$\begin{aligned} \text{sets H}_3\text{PO}_4 &= 0.1428717 \text{ mol H}_3\text{PO}_4 \\ & \times \frac{1 \text{ set H}_3\text{PO}_4}{2 \text{ mol H}_3\text{PO}_4} \\ & = 7.14358 \text{ E} \\ & - 2 \text{ mol H}_3\text{PO}_4 \end{aligned}$$

→ $\text{Ca}(\text{OH})_2$ is the limiting reagent, has fewer "sets"

Or

$$\frac{0.20242 \text{ mol of Ca}(\text{OH})_2 \times \frac{2 \text{ mol of H}_3\text{PO}_4}{3 \text{ mol of Ca}(\text{OH})_2}}{}$$

$$= 0.136193 \text{ mol H}_3\text{PO}_4$$

Since we have more than that much of H_3PO_4 $\text{Ca}(\text{OH})_2$ is limiting

Calculate the mass of $\text{Ca}_3(\text{PO}_4)_2$:

$$\begin{aligned} \text{mass Ca}_3(\text{PO}_4)_2 &= 0.20242 \text{ mol Ca}(\text{OH})_2 \times \frac{1 \text{ mol Ca}_3(\text{PO}_4)_2}{3 \text{ mol Ca}(\text{OH})_2} \times \frac{310.18 \text{ g Ca}_3(\text{PO}_4)_2}{1 \text{ mol Ca}_3(\text{PO}_4)_2} \\ &= 20.9298 = 20.93 \text{ g Ca}_3(\text{PO}_4)_2 \end{aligned}$$