Limiting Reagent

Exercise 20

What is the theoretical yield of $Ca_3(PO_4)_2(s)$ by the reaction

$$3\ Ca(OH)_2(s) + 2\ H_3PO_4(l) \rightarrow Ca_3(PO_4)_2(s) + 6\ H_2O(l)$$

when 10.00 g $Ca(OH)_2$ and 10.00 g H_3PO_4 are mixed? [F.W. $Ca(OH)_2$ = 74.10 u; M.W. H_3PO_4 = 97.99 u; F.W. $Ca_3(PO_4)_2$ = 310.18 u]

Answer:

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

$$mol\ H_3PO_4\text{: } 10.00g\ H_3PO_4 \times \frac{1\ mol\ H_3PO_4}{97.99g\ H_3PO_4} = 0.10205\ mol\ H_3PO_4$$

Identify limiting reagent by dividing each number of moles by its stoichiometric coefficient in the balanced equation to determine the "sets" for each: $sets\ Ca(OH)_2\text{: } 0.13495 mol\ Ca(OH)_2 \times \frac{1\ \text{set}\ Ca(OH)_2}{3\ mol\ Ca(OH)_2} = 4.498425\text{E} - 2\ mol\ Ca(OH)_2$ $sets\ H_3PO_4 = 0.1020512297173181\ mol\ H_3PO_4 \times \frac{1\ set\ H_3PO_4}{2\ mol\ H_3PO_4} = 0.051025 mol\ H_3PO_4$	Or 0.13495 mol of Ca(OH)2 x $\frac{2\ mol\ of\ H3PO4}{3\ mol\ of\ Ca(OH)2}$ = 0.0899 mol H3PO4 Since we have more than that much of H3PO4 Ca(ON)2 is limiting

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

Calculate the mass of $Ca_3(PO_4)_2$:

$$mass\ Ca_3(PO_4)_2 = 0.13495\ mol\ Ca(OH)_2 \times \frac{1\ mol\ Ca_3(PO_4)_2}{3\ mol\ Ca(OH)_2} \times \frac{310.18g\ Ca_3(PO_4)_2}{1\ mol\ Ca_3(PO_4)_2}$$

$$= 13.95321 = 13.95g\ Ca_3(PO_4)_2$$

What is the theoretical yield of $Ca_3(PO_4)_2(s)$ by the reaction

$$3\ Ca(OH)_2(s) + 2\ H_3PO_4(l) \rightarrow Ca_3(PO_4)_2(s) + 6\ H_2O(l)$$

when 8.00 g $Ca(OH)_2$ and 11.00 g H_3PO_4 are mixed? [F.W. $Ca(OH)_2$ = 74.10 u; M.W. H_3PO_4 = 97.99 u; F.W. $Ca_3(PO_4)_2$ = 310.18 u]

Answer

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

$$mol\ H_3PO_4: 11.00g\ H_3PO_4 \times \frac{1\ mol\ H_3PO_4}{97.99g\ H_3PO_4} = 0.112256 mol\ H_3PO_4$$

Identify limiting reagent by dividing each number of moles by its stoichiometric coefficient in the balanced equation to determine the “sets” for each: $sets\ Ca(OH)_2: 0.107962213\ mol\ Ca(OH)_2 \times \frac{1 \text{ set } Ca(OH)_2}{3\ mol\ Ca(OH)_2} = 0.0359874\ mol\ Ca(OH)_2$ $sets\ H_3PO_4 = 0.11225\ mol\ H_3PO_4 \times \frac{1\ set\ H_3PO_4}{2\ mol\ H_3PO_4} = 5.612817\text{ E} - 2\ mol\ H_3PO_4$ → $Ca(OH)_2$ is the limiting reagent, has fewer “sets”	Or 0.107962_mol of Ca(OH)2 x $\frac{2\ mol\ of\ H3PO4}{3\ mol\ of\ Ca(OH)2}$ = _071974________ mol H3PO4 Since we have more than that much of H3PO4 Ca(ON)2 is limiting

Calculate the mass of $Ca_3(PO_4)_2$:

$$mass\ Ca_3(PO_4)_2 = 0.107962\ mol\ Ca(OH)_2 \times \frac{1\ mol\ Ca_3(PO_4)_2}{3\ mol\ Ca(OH)_2} \times \frac{310.18g\ Ca_3(PO_4)_2}{1\ mol\ Ca_3(PO_4)_2}$$
$$= 11.162573 = 11.2g\ Ca_3(PO_4)_2$$

What is the theoretical yield of $Ca_3(PO_4)_2(s)$ by the reaction

$$3\ Ca(OH)_2(s) + 2\ H_3PO_4(l) \rightarrow Ca_3(PO_4)_2(s) + 6\ H_2O(l)$$

when 12.00 g $Ca(OH)_2$ and 12.00 g H_3PO_4 are mixed? [F.W. $Ca(OH)_2$ = 74.10 u; M.W. H_3PO_4 = 97.99 u; F.W. $Ca_3(PO_4)_2$ = 310.18 u]

Answer:

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

$$mol\ H_3PO_4: 12.00g\ H_3PO_4 \times \frac{1\ mol\ H_3PO_4}{97.99g\ H_3PO_4} = 0.122461\ mol\ H_3PO_4$$

Identify limiting reagent by dividing each number of moles by its stoichiometric coefficient in the balanced equation to determine the "sets" for each: $sets\ Ca(OH)_2: 0.161943\ mol\ Ca(OH)_2 \times \frac{1\ \text{set}\ Ca(OH)_2}{3\ mol\ Ca(OH)_2} = 5.39811E - 2\ mol\ Ca(OH)_2$ $sets\ H_3PO_4 = 0.122461\ mol\ H_3PO_4 \times \frac{1\ set\ H_3PO_4}{2\ mol\ H_3PO_4} = 6.12307\ E - 2\ mol\ H_3PO_4$ → $Ca(OH)_2$ is the limiting reagent, has fewer "sets"	Or _0.161943 ____mol of Ca(OH)2 x $\frac{2\ mol\ of\ H3PO4}{3\ mol\ of\ Ca(OH)2}$ = __0.107933_______ mol H3PO4 Since we have more than that much of H3PO4 Ca(ON)2 is limiting	

Calculate the mass of $Ca_3(PO_4)_2$:

$$mass\ Ca_3(PO_4)_2 = 0.161943\ mol\ Ca(OH)_2 \times \frac{1\ mol\ Ca_3(PO_4)_2}{3\ mol\ Ca(OH)_2} \times \frac{310.18g\ Ca_3(PO_4)_2}{1\ mol\ Ca_3(PO_4)_2} = 16.74385 = 16.74g\ Ca_3(PO_4)_2$$

What is the theoretical yield of $Ca_3(PO_4)_2(s)$ by the reaction

$$3\ Ca(OH)_2(s) + 2\ H_3PO_4(l) \rightarrow Ca_3(PO_4)_2(s) + 6\ H_2O(l)$$

when 15.00 g $Ca(OH)_2$ and 14.00 g H_3PO_4 are mixed? [F.W. $Ca(OH)_2$ = 74.10 u; M.W. H_3PO_4 = 97.99 u; F.W. $Ca_3(PO_4)_2$ = 310.18 u]

Answer:

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

$$mol\ H_3PO_4\text{: } 14.00\ g\ H_3PO_4 \times \frac{1\ mol\ H_3PO_4}{97.99 g\ H_3PO_4} = 0.142871\ mol\ H_3PO_4$$

Identify limiting reagent by dividing each number of moles by its stoichiometric coefficient in the balanced equation to determine the "sets" for each: $sets\ Ca(OH)_2\text{: } 0.202429\ mol\ Ca(OH)_2 \times \frac{1\text{ set } Ca(OH)_2}{3\ mol\ Ca(OH)_2} = 6.74763\text{E} - 2\ mol\ Ca(OH)_2$ $sets\ H_3PO_4 = 0.1428717\ mol\ H_3PO_4 \times \frac{1\ set\ H_3PO_4}{2\ mol\ H_3PO_4} = 7.14358\text{ E} - 2\ mol\ H_3PO_4$ → $Ca(OH)_2$ is the limiting reagent, has fewer "sets"	Or _0.20242____mol of Ca(OH)2 x $\frac{2\ mol\ of\ H3PO4}{3\ mol\ of\ Ca(OH)2}$ = _0.136193________ mol H3PO4 Since we have more than that much of H3PO4 Ca(ON)2 is limiting

Calculate the mass of $Ca_3(PO_4)_2$:

$$mass\ Ca_3(PO_4)_2 = 0.20242\ mol\ Ca(OH)_2 \times \frac{1\ mol\ Ca_3(PO_4)_2}{3\ mol\ Ca(OH)_2} \times \frac{310.18 g\ Ca_3(PO_4)_2}{1\ mol\ Ca_3(PO_4)_2}$$
$$= 20.9298 = 20.93\ g\ Ca_3(PO_4)_2$$