

4 Limiting Reactant

Name: Kaghad darwish Section
 Lab. Instructor Date

Pre-Laboratory Questions

1. $\text{Na}_3\text{PO}_4 \cdot 12\text{H}_2\text{O}$ and $\text{BaCl}_2 \cdot 2\text{H}_2\text{O}$ are examples of compounds known as hydrates. Calculate the molar masses of Na_3PO_4 and BaCl_2 in the hydrated and anhydrous forms.

Hydrates: molecules contain water molecules: (H_2O)

Example: $\text{Al}(\text{SO}_4)_3 \cdot x\text{H}_2\text{O}$
 $\text{Al}(\text{SO}_4)_3$
 $\text{BaCl}_2 \cdot 2\text{H}_2\text{O}$
 $137.3 + 2 \times 35.45 + 2 \times 2 + 2 \times 16$
 $= 240 \times 10^2$
 $\text{BaCl}_2 = 208 \times 10^2$

(MW) $\text{Na}_3\text{PO}_4 \cdot 12\text{H}_2\text{O} = (3 \times 22.99 + 30.97 + 4 \times 16 + 2 \times 12 + 12 \times 18) = 380.12 \times 10^2$
 $\text{Na}_3\text{PO}_4 = 163.97 \times 10^2$

2. A mixture of 0.28 g $\text{BaCl}_2 \cdot 2\text{H}_2\text{O}$ and 0.72 g $\text{Na}_3\text{PO}_4 \cdot 12\text{H}_2\text{O}$ was dissolved in water. Which of the two reactants is the limiting reactant? Calculate the mass of the precipitate formed, $\text{Ba}_3(\text{PO}_4)_2$.

$3 \text{BaCl}_2 \cdot 2\text{H}_2\text{O} + 2 \text{Na}_3\text{PO}_4 \cdot 12\text{H}_2\text{O} \rightarrow \text{Ba}_3(\text{PO}_4)_2 + 6\text{NaCl}$
 $m = 0.28 \text{ g}$ $m = 0.72 \text{ g}$ $m = ?$
 MW = 240.2 g/mol MW = 380.12 g/mol MW = 601.84 g/mol
 $n = 1.16 \times 10^{-3}$ $n = 1.89 \times 10^{-3}$
 $\frac{n}{3} = 3.82 \times 10^{-4}$ $\frac{n}{2} = 9.4 \times 10^{-4}$

$\text{BaCl}_2 \cdot 2\text{H}_2\text{O}$ is the limiting reactant.

$3 \text{ mol BaCl}_2 \cdot 2\text{H}_2\text{O} \rightarrow 1 \text{ mol Ba}_3(\text{PO}_4)_2$
 $1.16 \times 10^{-3} \text{ mol} \rightarrow ?$
 $? = 3.82 \times 10^{-4} \text{ mol Ba}_3(\text{PO}_4)_2$
 $n \times \frac{\text{mass}}{\text{m.m.}} = 0.230 \text{ g}$

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Results and Calculations

A. Precipitation of $Ba_3(PO_4)_2$:

Unknown Number: 5

Mass of salt mixture (m_1)	0.75	g
Mass of filter paper (m_2)	0.58	g
Mass of filter paper and $Ba_3(PO_4)_2$ (m_3)	0.86	g

B. Determination of the Limiting Reactant:

Limiting reactant in salt mixture is Na_3PO_4

Excess reactant in salt mixture is $BaCl_2$

Mass of $Ba_3(PO_4)_2$ precipitated ($m_3 - m_2$)	0.28	g
Number of moles of $Ba_3(PO_4)_2$ precipitated (n_1)	$\frac{0.28}{601.93} = 4.65 \times 10^{-4}$	mol

(a) If the limiting reactant is $BaCl_2 \cdot 2H_2O$:

Number of moles of $BaCl_2 \cdot 2H_2O$ reacted (n_2)		mol
Number of moles of $Na_3PO_4 \cdot 2H_2O$ reacted (n_3)		mol
Mass of $BaCl_2 \cdot 2H_2O$ reacted (m_4)		g
Mass of Na_3PO_4 reacted (m_5)		g
Mass of excess Na_3PO_4 [$m_1 - (m_4 + m_5)$]		g
Mass percentage of $BaCl_2 \cdot 2H_2O$		%

(b) If the limiting reactant is $\text{Na}_3\text{PO}_4 \cdot 12\text{H}_2\text{O}$:

Number of mole of $\text{Na}_3\text{PO}_4 \cdot 12\text{H}_2\text{O}$ reacted (n_2)	9.3×10^{-4} mol
Number of moles of $\text{BaCl}_2 \cdot 2\text{H}_2\text{O}$ reacted (n_3)	1.39×10^{-3} mol
Mass of $\text{Na}_3\text{PO}_4 \cdot 12\text{H}_2\text{O}$ reacted (m_4)	35356 g
Mass of $\text{BaCl}_2 \cdot 2\text{H}_2\text{O}$ reacted (m_5)	3395 g
Mass of excess $\text{BaCl}_2 \cdot 2\text{H}_2\text{O}$ [$m_1 - (m_4 + m_5)$]	6.94×10^3 g $27 - (35356 + 3395)$ g
Mass percentage of $\text{Na}_3\text{PO}_4 \cdot 12\text{H}_2\text{O}$	$\frac{35356}{27} \times 100$ % 50.51

$$\text{mm Ba(PO}_4)_2 = 601.93$$

$$n \text{ Ba(PO}_4)_2 =$$

$$n \text{ Ba}^{+2} \quad 4.65 \times 10^{-4} (3) = 1.39 \times 10^{-3}$$

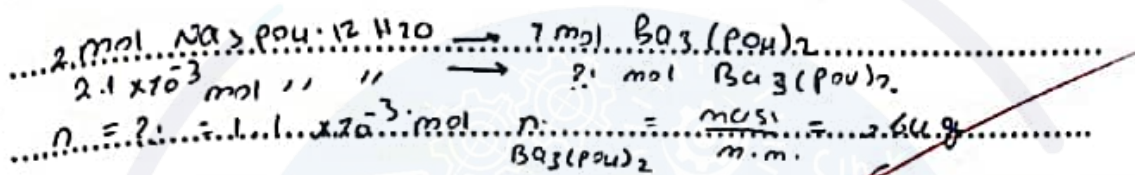
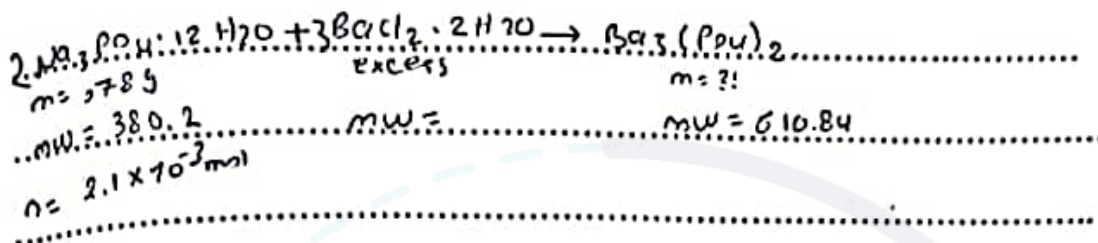
$$n \text{ PO}_4^{-3} \quad 4.65 \times 10^{-4} (2) = 9.3 \times 10^{-4}$$

$$\text{mass BaCl}_2 \cdot 2\text{H}_2\text{O} = (1.39 \times 10^{-3}) \times (244.27) = 3395$$

$$\text{Na}_3\text{PO}_4 \cdot 12\text{H}_2\text{O} = (9.3 \times 10^{-4}) (380.12) = 3535$$

QUESTIONS

1. Calculate the mass of $Ba_3(PO_4)_2$ produced from the reaction of 0.78 g $Na_3PO_4 \cdot 12H_2O$ with excess $BaCl_2 \cdot 2H_2O$. What is the purpose of heating the mixture in step 3 for 20 minutes?



we heat to increase amount of product by complete the reaction

2. What is the purpose of washing the precipitate with hot water in step 4?
 How would the reported percentage of the excess reactant be affected if the precipitate was not washed in this step?

To remove excess reactant and impurities from the precipitate.

If the precipitate was not washed:

Mass of precipitate will increase so the mass of limiting

reactant will increase so the mass of the excess will

decrease finally the percentage of the excess will

decrease.