

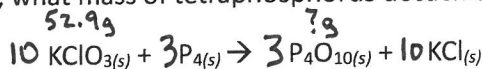
Unit 3 – Chapter 3: Stoichiometry

Name KEY

Assignment #3: Basic Stoichiometry, Limiting Reagents, % Yield

Period _____

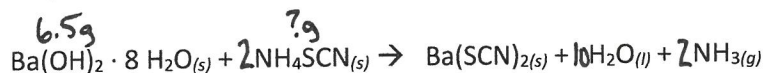
- 1) The reaction between potassium chlorate and red phosphorus takes place when you strike a match on a matchbox. If you were to react 52.9 g of potassium chlorate (KClO_3) with excess red phosphorus, what mass of tetraphosphorus decaoxide (P_4O_{10}) would be produced?



UNBALANCED

$$\frac{52.9 \text{ g KClO}_3}{122.5 \text{ g KClO}_3} \times \frac{1 \text{ mol KClO}_3}{10 \text{ mol KClO}_3} \times \frac{3 \text{ mol P}_4\text{O}_{10}}{1 \text{ mol P}_4\text{O}_{10}} \times \frac{283.8 \text{ g P}_4\text{O}_{10}}{1 \text{ mol P}_4\text{O}_{10}} = 36.8 \text{ g P}_4\text{O}_{10}$$

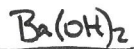
- 2) One of the relatively few reactions that takes place directly between two solids at room temperature is



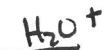
a. Balance this equation.

b. What mass of ammonium thiocyanate (NH_4SCN) must be used if it is to react completely with 6.5 g barium hydroxide octahydrate?

$$\frac{6.5 \text{ g Ba}(\text{OH})_2 \cdot 8 \text{H}_2\text{O}}{315 \text{ g Ba}(\text{OH})_2 \cdot 8 \text{H}_2\text{O}} \times \frac{1 \text{ mol Ba}(\text{OH})_2 \cdot 8 \text{H}_2\text{O}}{1 \text{ mol Ba}(\text{OH})_2 \cdot 8 \text{H}_2\text{O}} \times \frac{2 \text{ mol NH}_4\text{SCN}}{1 \text{ mol Ba}(\text{OH})_2 \cdot 8 \text{H}_2\text{O}} \times \frac{76 \text{ g NH}_4\text{SCN}}{1 \text{ mol NH}_4\text{SCN}} = 3.1 \text{ g NH}_4\text{SCN}$$

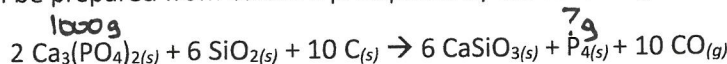


$$\begin{aligned} 1 \text{ Ba} \times 137 &= 137 \\ 2 \text{ O} \times 16 &= 32 \\ 2 \text{ H} \times 1 &= 2 \\ \hline &171 \text{ g/mol} \end{aligned}$$



$$\begin{aligned} 8 \times 18 &= 144 \\ \hline &315 \text{ g} \end{aligned}$$

- 3) Phosphorus can be prepared from calcium phosphate by the following reaction:

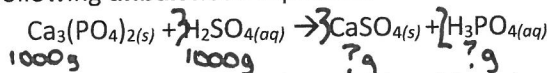


Phosphorite is a mineral that contains $\text{Ca}_3(\text{PO}_4)_2$ plus other non-phosphorus-containing compounds. What is the maximum amount of P_4 that can be produced from 1.0 kg of phosphorite if the phosphorite sample is 75% $\text{Ca}_3(\text{PO}_4)_2$ by mass? Assume an excess of the other reactants.

$$\% \text{YIELD} = \frac{\text{ACTUAL}}{\text{THEORETICAL}} \rightarrow \text{ACTUAL} = \% \text{YIELD} \times \text{THEORETICAL}$$

$$\frac{1000 \text{ g} \times 0.75 = 750 \text{ g Ca}_3(\text{PO}_4)_2}{310.18 \text{ g Ca}_3(\text{PO}_4)_2} \times \frac{1 \text{ mol Ca}_3(\text{PO}_4)_2}{2 \text{ mol Ca}_3(\text{PO}_4)_2} \times \frac{1 \text{ mol P}_4}{1 \text{ mol P}_4} \times \frac{123.88 \text{ g P}_4}{1 \text{ mol P}_4} = 150 \text{ g P}_4$$

- 4) Consider the following **unbalanced** equation:



What masses of calcium sulfate and phosphoric acid can be produced from the reaction of 1.0 kg of calcium phosphate with 1.0 kg of concentrated sulfuric acid (98% H_2SO_4 by mass)?

$$\begin{aligned} \text{LR} \rightarrow & \frac{1000 \text{ g Ca}_3(\text{PO}_4)_2}{310.18 \text{ g Ca}_3(\text{PO}_4)_2} \times \frac{1 \text{ mol Ca}_3(\text{PO}_4)_2}{3 \text{ mol CaSO}_4} \times \frac{136.15 \text{ g CaSO}_4}{1 \text{ mol CaSO}_4} = 1316.6 \text{ g CaSO}_4 \\ & \frac{1000 \text{ g H}_2\text{SO}_4 \times 0.98 = 980 \text{ g H}_2\text{SO}_4}{98 \text{ g H}_2\text{SO}_4} \times \frac{1 \text{ mol H}_2\text{SO}_4}{3 \text{ mol H}_2\text{SO}_4} \times \frac{136.15 \text{ g CaSO}_4}{1 \text{ mol CaSO}_4} = 1361.5 \text{ g CaSO}_4 \\ & \frac{1000 \text{ g Ca}_3(\text{PO}_4)_2}{310.18 \text{ g Ca}_3(\text{PO}_4)_2} \times \frac{1 \text{ mol Ca}_3(\text{PO}_4)_2}{2 \text{ mol H}_3\text{PO}_4} \times \frac{97.99 \text{ g H}_3\text{PO}_4}{1 \text{ mol H}_3\text{PO}_4} = 631.8 \\ & = 630 \text{ g H}_3\text{PO}_4 \end{aligned}$$

- 5) DDT, an insecticide harmful to fish, birds, and humans, is produced by the following reaction:



In a government lab, 1142 g of chlorobenzene is reacted with 485 g of chloral.

- What mass of DDT is formed?
- Which reactant is limiting? Which is in excess?
- What mass of excess reactant is left over?
- If the actual yield of DDT is 200.0 g, what is the percent yield?

ER ↓

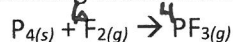
$$\frac{1142 \text{ g C}_6\text{H}_5\text{Cl}}{112.55 \text{ g C}_6\text{H}_5\text{Cl}} \times \frac{1 \text{ mol C}_6\text{H}_5\text{Cl}}{2 \text{ mol C}_6\text{H}_5\text{Cl}} \times \frac{1 \text{ mol DDT}}{1 \text{ mol DDT}} \times \frac{354.60 \text{ g DDT}}{1 \text{ mol DDT}} = 1798.99 \text{ g DDT}$$

$$\frac{485 \text{ g C}_2\text{HOCl}_3}{147.38 \text{ g C}_2\text{HOCl}_3} \times \frac{1 \text{ mol C}_2\text{HOCl}_3}{1 \text{ mol C}_2\text{HOCl}_3} \times \frac{1 \text{ mol DDT}}{1 \text{ mol DDT}} \times \frac{354.60 \text{ g DDT}}{1 \text{ mol DDT}} = 1169.7 \text{ g DDT}$$

c) $\frac{629.29 \text{ g DDT}}{\text{Difference}} \times \frac{1 \text{ mol DDT}}{354.60 \text{ g DDT}} \times \frac{2 \text{ mol C}_6\text{H}_5\text{Cl}}{1 \text{ mol DDT}} \times \frac{112.55 \text{ g C}_6\text{H}_5\text{Cl}}{1 \text{ mol C}_6\text{H}_5\text{Cl}} = 399.5 \text{ g EXCESS}$

d) $\frac{200.0 \text{ g}}{1169.7 \text{ g}} \times 100\% = 17.0\%$

- 6) Consider the following **unbalanced** reaction:



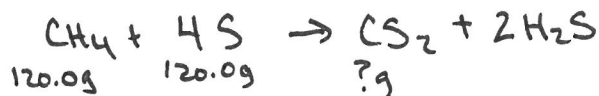
What mass of F_2 is needed to produce 120.0 g of PF_3 if the reaction has a 78.1% yield?

78.1% = $\frac{120.0 \text{ g PF}_3}{x \text{ g (THEORETICAL)}}$ → ACTUAL!

$$x = 153.6 \text{ g PF}_3 \times \frac{1 \text{ mol PF}_3}{87.97 \text{ g PF}_3} \times \frac{6 \text{ mol F}_2}{4 \text{ mol PF}_3} \times \frac{38 \text{ g F}_2}{1 \text{ mol F}_2} = 99.8 \text{ g F}_2 \text{ NEEDED}$$

- 7) Methane (CH_4) is the main component of marsh gas. Heating methane in the presence of sulfur produces carbon disulfide and hydrogen sulfide as the only products.

- Write the balanced chemical equation for the reaction of methane and sulfur.
- Calculate the theoretical yield of carbon disulfide when 120.0 g of methane is reacted with an equal mass of sulfur.



ER ↓

$$\frac{120.0 \text{ g CH}_4}{16 \text{ g CH}_4} \times \frac{1 \text{ mol CH}_4}{1 \text{ mol CH}_4} \times \frac{1 \text{ mol CS}_2}{1 \text{ mol CH}_4} \times \frac{76.02 \text{ g CS}_2}{1 \text{ mol CS}_2} = 570.15 \text{ g CS}_2$$

LR ↑

$$\frac{120.0 \text{ g S}}{32.01 \text{ g S}} \times \frac{1 \text{ mol S}}{4 \text{ mol S}} \times \frac{1 \text{ mol CS}_2}{1 \text{ mol S}} \times \frac{76.02 \text{ g CS}_2}{1 \text{ mol CS}_2} = 71.3 \text{ g CS}_2$$