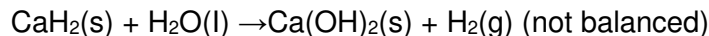
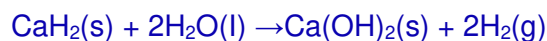


1. The reaction of calcium hydride with water can be used to prepare small quantities of hydrogen gas, as is done to fill weather-observation balloons.



- (a) How many grams of water are consumed in the reaction of 56.2 g CaH_2 ?
 (b) What mass of $\text{CaH}_2(\text{s})$ must react with an excess of water to produce 8.12×10^{24} molecules of H_2 ?



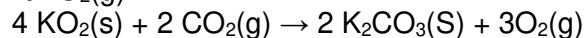
a)

$$56.2\text{g CaH}_2 \times \frac{1 \text{ mol CaH}_2}{42.10 \text{ g CaH}_2} \times \frac{2 \text{ mol H}_2\text{O}}{1 \text{ mol CaH}_2} \times \frac{18.02 \text{ g H}_2\text{O}}{1 \text{ mol H}_2\text{O}} = \mathbf{48.1 \text{ g H}_2\text{O}}$$

b)

$$8.12 \times 10^{24} \text{ molec. H}_2 \times \frac{1 \text{ mol H}_2}{6.02 \times 10^{23} \text{ molec.}} \times \frac{1 \text{ mol CaH}_2}{2 \text{ mol H}_2} \times \frac{42.10 \text{ g CaH}_2}{1 \text{ mol CaH}_2} = \mathbf{284 \text{ g CaH}_2}$$

2. The reaction of potassium superoxide, KO_2 , is used in life-support systems to replace $\text{CO}_2(\text{g})$ in expired air with $\text{O}_2(\text{g})$.



- (a) How many moles of $\text{O}_2(\text{g})$ are produced by the reaction of 156 g CO_2 with excess KO_2 ?
 (b) How many grams of KO_2 are consumed per 100.0 g CO_2 removed from expired air?

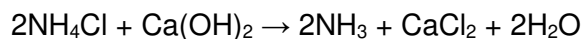
a)

$$156\text{g CO}_2 \times \frac{1 \text{ mol CO}_2}{44.01 \text{ g CO}_2} \times \frac{3 \text{ mol O}_2}{2 \text{ mol CO}_2} = \mathbf{5.32 \text{ mol O}_2}$$

b)

$$100\text{g CO}_2 \times \frac{1 \text{ mol CO}_2}{44.01 \text{ g CO}_2} \times \frac{4 \text{ mol KO}_2}{2 \text{ mol CO}_2} \times \frac{71.10 \text{ g KO}_2}{1 \text{ mol KO}_2} = \mathbf{323 \text{ g KO}_2}$$

3. Ammonia can be generated by heating together the solids NH_4Cl and $\text{Ca}(\text{OH})_2$ with CaCl_2 and H_2O also being formed. **(a)** If a mixture containing 33.0 g each of NH_4Cl and $\text{Ca}(\text{OH})_2$ is heated, how many grams of NH_3 will form? **(b)** Which reactant remains in excess, and in what mass?



a)

Find limiting reactant

$$33.0\text{g NH}_4\text{Cl} \times \frac{1 \text{ mol NH}_4\text{Cl}}{53.50 \text{ g NH}_4\text{Cl}} \times \frac{2 \text{ mol NH}_3}{2 \text{ mol NH}_4\text{Cl}} \times \frac{17.04 \text{ g NH}_3}{1 \text{ mol NH}_3} = 10.5 \text{ g NH}_3$$

$$33.0\text{g Ca}(\text{OH})_2 \times \frac{1 \text{ mol Ca}(\text{OH})_2}{74.10 \text{ g Ca}(\text{OH})_2} \times \frac{2 \text{ mol NH}_3}{1 \text{ mol Ca}(\text{OH})_2} \times \frac{17.04 \text{ g NH}_3}{1 \text{ mol NH}_3} = 15.2 \text{ g NH}_3$$

Therefore NH_4Cl is the limiting reactant and 10.5 g NH_3 can be made.

b)

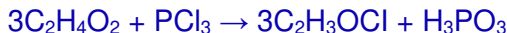
$$10.5 \text{ g NH}_3 \times \frac{1 \text{ mol NH}_3}{17.04 \text{ g NH}_3} \times \frac{1 \text{ mol Ca}(\text{OH})_2}{2 \text{ mol NH}_3} \times \frac{74.01 \text{ g Ca}(\text{OH})_2}{1 \text{ mol Ca}(\text{OH})_2} = 22.8 \text{ g Ca}(\text{OH})_2$$

Therefore 22.8 g $\text{Ca}(\text{OH})_2$ will be consumed and $(33.0 - 22.8)\text{g} = 10.2 \text{ g Ca}(\text{OH})_2$ will remain.

4. How many grams of acetic acid must be allowed to react with an excess of PCl_3 to produce 75 g of acetyl chloride ($\text{C}_2\text{H}_3\text{OCl}$), if the reaction has a 78.2% yield?



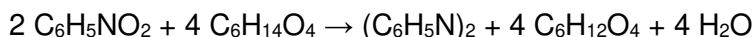
We need the theoretical yield to do the calculation:



Theoretical yield = actual yield/0.782 = 75g/0.782 = 95.9 g

$$95.9 \text{ g C}_2\text{H}_3\text{OCl} \times \frac{1 \text{ mol C}_2\text{H}_3\text{OCl}}{78.50 \text{ g C}_2\text{H}_3\text{OCl}} \times \frac{3 \text{ mol C}_2\text{H}_4\text{O}_2}{3 \text{ mol C}_2\text{H}_3\text{OCl}} \times \frac{60.06 \text{ g C}_2\text{H}_4\text{O}_2}{1 \text{ mol C}_2\text{H}_4\text{O}_2} = \mathbf{73.4 \text{ g C}_2\text{H}_4\text{O}_2}$$

5. Azobenzene ($(\text{C}_6\text{H}_5\text{N})_2$), an intermediate in the manufacture of dyes, can be prepared from nitrobenzene ($\text{C}_6\text{H}_5\text{NO}_2$) by reaction with triethylene glycol ($\text{C}_6\text{H}_{14}\text{O}_4$). In one reaction, 0.10 L of nitrobenzene ($d = 1.20 \text{ g/mL}$) and 0.30 L of triethylene glycol ($d = 1.12 \text{ g/mL}$) yields 55 g azobenzene. What are the (a) theoretical yield, (b) actual yield, and (c) percent yield of this reaction?



a)

$$100 \text{ mL C}_6\text{H}_5\text{NO}_2 \times \frac{1.20 \text{ g C}_6\text{H}_5\text{NO}_2}{1 \text{ mL C}_6\text{H}_5\text{NO}_2} \times \frac{1 \text{ mol C}_6\text{H}_5\text{NO}_2}{123.1 \text{ g C}_6\text{H}_5\text{NO}_2} \times \frac{1 \text{ mol } (\text{C}_6\text{H}_5\text{N})_2}{2 \text{ mol C}_6\text{H}_5\text{NO}_2} = 0.487 \text{ mol } (\text{C}_6\text{H}_5\text{N})_2$$

$$300 \text{ mL C}_6\text{H}_{14}\text{O}_4 \times \frac{1.12 \text{ g C}_6\text{H}_{14}\text{O}_4}{1 \text{ mL C}_6\text{H}_{14}\text{O}_4} \times \frac{1 \text{ mol C}_6\text{H}_{14}\text{O}_4}{150.2 \text{ g C}_6\text{H}_{14}\text{O}_4} \times \frac{1 \text{ mol } (\text{C}_6\text{H}_5\text{N})_2}{4 \text{ mol C}_6\text{H}_{14}\text{O}_4} = 0.559 \text{ mol } (\text{C}_6\text{H}_5\text{N})_2$$

So, $\text{C}_6\text{H}_5\text{NO}_2$ is our limiting reactant and our theoretical yield is:

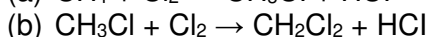
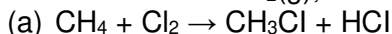
$$0.487 \text{ mol } (\text{C}_6\text{H}_5\text{N})_2 \times \frac{182.26 \text{ g } (\text{C}_6\text{H}_5\text{N})_2}{1 \text{ mol } (\text{C}_6\text{H}_5\text{N})_2} = \mathbf{88.8 \text{ g } (\text{C}_6\text{H}_5\text{N})_2}$$

b) The actual yield is **55 g**

c)

$$\% \text{ yield} = \frac{55 \text{ g}}{89 \text{ g}} \times 100\% = \mathbf{62 \% \text{ yield}}$$

6. Suppose that reactions (a) and (b) have a 92% yield. Starting with 112 g CH_4 in reaction (a) and an excess of $\text{Cl}_2(\text{g})$, how many grams of CH_2Cl_2 are formed in reaction (b)?



$$112 \text{ g CH}_4 \times \frac{1 \text{ mol CH}_4}{16.05 \text{ g CH}_4} \times \frac{1 \text{ mol CH}_3\text{Cl}}{1 \text{ mol CH}_4} = 6.98 \text{ mol CH}_3\text{Cl}$$

So, the theoretical yield of reaction (a) is 6.98 mol, but the % yield is 92%, so the actual yield is $6.98 \text{ mol} \times 0.92 = 6.42 \text{ mol CH}_3\text{Cl}$. This quantity continues to reaction (b)

$$6.42 \text{ mol CH}_3\text{Cl} \times \frac{1 \text{ mol CH}_2\text{Cl}_2}{1 \text{ mol CH}_3\text{Cl}} \times \frac{84.93 \text{ g CH}_2\text{Cl}_2}{1 \text{ mol CH}_2\text{Cl}_2} = 545.2 \text{ g CH}_2\text{Cl}_2$$

So, the theoretical yield of reaction (b) is 545.2 g CH_2Cl_2 , but the % yield is 92%, so the actual yield is $545.2 \text{ g CH}_2\text{Cl}_2 \times 0.92 = \mathbf{502 \text{ g CH}_2\text{Cl}_2}$.