Limiting Reactants Practice

Name: Key

1. A sample of a solution containing 100 grams of copper (II) chloride is reacted with a solution containing 40 grams of sodium hydroxide.
   a. Write the balanced chemical equation for the reaction, using the state symbols.

Step 1

$$CuCl_{2(aq)} + 2NaOH_{(aq)} \rightarrow 2NaCl_{(aq)} + Cu(OH)_{2(s)}$$

Step 2 - moles we have of reactants

$\frac{100\,g\,CuCl_2 \mid 1\,mol}{\mid 134.45\,g} = 0.74\,mol\,CuCl_2$

$\frac{40\,g\,NaOH \mid 1\,mol}{\mid 39.98\,g} = 1\,mol\,NaOH$ ★This is the magic number!

   b. Determine the mass in grams of each product produced and the amount of the excess reactant that remains.

Product 1 $Cu(OH)_2$: Amount Produced 48.78g

Product 2 NaCl : Amount Produced 55.85g

Excess Reactant $CuCl_2$: Amount Remaining 32.77g

Step 3 - moles we need to react completely

$\frac{0.74\,mol\,CuCl_2 \mid 2\,mol\,NaOH}{\mid 1\,mol\,CuCl_2} = 1.48\,mol\,NaOH$ ← This # is greater than what we have, so...

NaOH is LR

Step 4 & 5 Calculate mass of excess used + left over

Step 4 $\frac{1\,mol\,NaOH \mid 1\,mol\,CuCl_2 \mid 134.45\,g\,CuCl_2}{\mid 2\,mol\,NaOH \mid 1\,mol\,CuCl_2} = 67.23\,g\,CuCl_2$ used

Step 5 $100\,g - 67.23\,g = 32.77\,g\,CuCl_2$ leftover

Step 6 Calculate mass produced of products — USE LR!

$\frac{1\,mol\,NaOH \mid 1\,mol\,Cu(OH)_2 \mid 97.56\,g\,Cu(OH)_2}{\mid 2\,mol\,NaOH \mid 1\,mol\,Cu(OH)_2} = 48.78\,g\,Cu(OH)_2$

$\frac{1\,mol\,NaOH \mid 2\,mol\,NaCl \mid 55.85\,g\,NaCl}{\mid 2\,mol\,NaOH \mid 1\,mol\,NaCl} = 55.85\,g\,NaCl$ (... sig figs applied ...)

2. A sample of a solution containing 90 grams of iron (III) nitrate is reacted with a solution containing 20 grams of potassium hydroxide.

a. Write the balanced chemical equation for the reaction, using the state symbols.

Step 1 $Fe(NO_3)_{3(aq)} + 3KOH_{(aq)} \rightarrow Fe(OH)_{3(s)} + 3KNO_{3(aq)}$

Step 2

$\frac{90g\ Fe(NO_3)_3 \mid 1mol}{\mid 241.86g} = 0.37mol\ Fe(NO_3)_3$ $\frac{20g\ KOH \mid 1mol}{\mid 56.1g} = 0.36mol\ KOH$

b. Determine the mass in grams of each product produced and the amount of the excess reactant that remains.

Product 1 $Fe(OH)_3$: Amount Produced 10.66g

Product 2 KNO_3 : Amount Produced 36.40g

Excess Reactant $Fe(NO_3)_3$: Amount Remaining 60.98g

magic number

step 3 $\frac{.36mol\ KOH \mid 1mol\ Fe(NO_3)_3}{\mid 3mol\ KOH} = 0.12mol\ Fe(NO_3)_3$ needed, so KOH is LR

step 4+5 $\frac{0.12mol \mid 241.86g}{\mid 1mol} = 29.02g$

90.00g $Fe(NO_3)_3$ given
− 29.02g $Fe(NO_3)_3$ used
60.98g $Fe(NO_3)_3$ remaining

step 6 $\frac{0.36mol\ KOH \mid Fe(OH)_3 \mid 88.86g}{\mid 3mol\ KOH \mid 1mol} = 10.66$

$\frac{0.36mol\ KOH \mid 3 \mid 101.1g}{\mid 3 \mid 1mol\ KNO_3} = 36.40g$

3. Forty grams of magnesium is reacted with an excess of oxygen. How much oxygen is used in the reaction?

this allows us to skip a couple steps

step 1 $2Mg_{(s)} + O_{2(g)} \rightarrow 2MgO_{(s)}$

Step 2 & Step 4

$\frac{40g\ Mg \mid 1mol\ Mg \mid 1mol\ O_2 \mid 32g\ O_2}{\mid 24.3g\ Mg \mid 2mol\ Mg \mid 1mol\ O_2}$

$26.34g\ O_2$

4. In a container, 100 grams of iron is combined with 100 grams of oxygen to form iron (II) oxide.

a. How much iron (II) oxide is produced?

step 1 $2Fe_{(s)} + O_{2(g)} \rightarrow 2FeO_{(s)}$

step 2 $\frac{100\,g\,Fe}{} \Big| \frac{1\,mol}{55.85\,g} = 1.79\,mol\,Fe$ (magic number) $\frac{100\,g\,O_2}{} \Big| \frac{1\,mol}{32\,g} = 3.13\,mol\,O_2$

step 3 $\frac{3.13\,mol\,O_2}{} \Big| \frac{2\,mol\,Fe}{1\,mol\,O_2} = 6.26\,mol\,Fe$ Fe is LR

step 6 $\frac{1.79\,mol\,Fe}{} \Big| \frac{2\,mol\,FeO}{2\,mol\,Fe} \Big| \frac{71.84\,g}{1\,mol\,FeO} = 128.59\,g$ FeO produced

b. Which element is the limiting reactant? Fe

c. How much of the excess reactant does not react?

step 4 + 5 $\frac{1.79\,mol\,Fe}{} \Big| \frac{1\,mol\,O_2}{2\,mol\,Fe} \Big| \frac{32\,g\,O_2}{1\,mol\,O_2} =$ 28.64 g O_2 used

100 g O_2 give − 28.64 g O_2 used = 71.36 g O_2 left

5. Seventy grams of silver are allowed to react with 50 grams of bromine to form silver bromide, a compound found in eyeglass lenses.

a. How much silver bromide is produced?

$2Ag_{(s)} + Br_{2(l)} \rightarrow 2AgBr_{(s)}$

$\frac{70\,g\,Ag}{} \Big| \frac{1\,mol}{107.87\,g} = 0.65\,mol\,Ag$ $\frac{50\,g\,Br_2}{} \Big| \frac{1\,mol}{159.8\,g} = 0.31\,mol\,Br_2$ (magic #)

$\frac{0.31\,mol\,Br_2}{} \Big| \frac{2\,mol\,Ag}{1\,mol\,Br_2} = 0.62\,mol\,Ag$ needed so Br_2 is LR

$\frac{0.31\,mol\,Br_2}{} \Big| \frac{2\,mol\,AgBr}{1\,mol\,Br_2} \Big| \frac{187.8\,g}{1\,mol\,AgBr} = 116.44\,g\,AgBr$

b. Which element is the limiting reactant? Br_2

c. How much of the excess reactant does not react?

$\frac{0.31\,mol\,Br_2}{} \Big| \frac{2\,mol\,Ag}{1\,mol\,Br_2} \Big| \frac{107.9\,g}{1\,mol\,Ag} =$ 66.90 g reacted

70.00 g − 66.90 g = 3.10 g Ag left

6. In a container, 30 grams of potassium is combined with 25 grams of nitrogen and potassium nitride is formed.
   a. How much potassium nitride is formed?

$6K_{(s)} + N_{2(g)} \rightarrow 2K_3N_{(s)}$

30g K | 1mol / 39.1g = 0.78 mol K ; 25g | 1mol / 28g = 0.89 mol N_2 — K limits

0.78 mol K | 1 mol N_2 / 6 mol K = 0.13 mol N_2 needed

0.78 mol K | 2 mol K_3N / 6 mol K | 131.3g / 1 mol K_3N = 34.138g K_3N produced

   b. What is the limiting reactant? K (potassium)

   c. How much of the excess reactant remains?

0.78 mol K | 1 mol N_2 / 6 mol K | 28g N_2 / 1 mol N_2 = 3.64g N_2 used; 25 − 3.64 = 21.36g left of N_2

7. And experiment combiners 1000 grams of sodium chloride is with 2000 grams of barium phosphate.
   a. Write a balanced equation for the reaction.

Step 1: $6NaCl_{(aq)} + Ba_3(PO_4)_{2(s)} \rightarrow 2Na_3PO_{4(aq)} + 3BaCl_{2(aq)}$

Step 2: 1000g NaCl | 1 mol / 55.85g = 17.91 mol NaCl (magic number!!); 2000g $Ba_3(PO_4)_2$ | 1 mol / 601.921g = 3.322 mol $Ba_3(PO_4)_2$

   b. What is the limiting reactant? NaCl

Step 3: 17.91 mol NaCl | 1 mol $Ba_3(PO_4)_2$ / 6 mol NaCl = 2.985 mol $Ba_3(PO_4)_2$ needed

We are not asked for step 6 here!

   c. How much of the excess reactant remains?

Step 4+5: 3.322 − 2.985 = 0.337 mol | 601.921 / 1 mol = 202.84g $Ba_3(PO_4)_2$ left

8. **BONUS**! (for fun) A chemist burns 160.0 g of Al in excess O_2 from the air over a Bunsen burner to produce aluminum oxide, Al_2O_3.

$4Al + 3O_2 \rightarrow 2Al_2O_3$

   a. Use the balanced equation to solve for how much aluminum oxide she could *theoretically* produce, given that the limiting reactant is Al.

160g Al | 1 mol Al / 26.98g | 2 mol Al_2O_3 / 4 mol Al | 101.96g / 1 mol Al_2O_3 = 302.33g

   b. She produces 260.0 g of solid aluminum oxide in the crucible. What is the percent yield of this experiment? (Just try it!!!!! Think about what a percent is…)

% yield = $\left(\frac{260g}{302.33g}\right) \times 100\%$ = 86% (pretty good!)