AP Chem In-class practice: Stoichiometry, limiting and excess reactants, percent yield!

1. Rxn: $3\ Zn_{(s)} + 8\ HNO_{3(aq)} \text{------>} 2\ NO_{(g)} + 4\ H_2O_{(g)} + 3\ Zn(NO_3)_{2(aq)}$

a. If 14.4 grams of zinc powder react with excess acid, how many molecules of water should form?

$$(14.4\text{ g Zn})\left(\frac{1\text{ mole}}{65.38\text{ g}}\right)\left(\frac{4\text{ mole } H_2O}{3\text{ mole Zn}}\right)\left(\frac{6.02\times10^{23}\text{ molecules}}{1\text{ mole}}\right) = \boxed{1.77\times10^{23}\text{ molecules}}$$

b. What mass of nitric acid will be consumed, when the 14.4 grams of zinc react?

$$(14.4\text{ g Zn})\left(\frac{1\text{ mole}}{65.38\text{ g}}\right)\left(\frac{8\text{ mole } HNO_3}{3\text{ mole Zn}}\right)\left(\frac{63.0128\text{ g}}{1\text{ mole}}\right) = \boxed{37.0\text{ g}}$$

c. If 18.0 grams of zinc are allowed to react with 0.658 moles of nitric acid, how many liters of NO gas should be collected, if measured at STP?

$$(18.0\text{ g Zn})\left(\frac{1\text{ mole}}{65.38\text{ g}}\right)\left(\frac{2\text{ mole NO}}{3\text{ mole Zn}}\right)\left(\frac{22.4\text{ L}}{1\text{ mole}}\right) = 4.1113 \rightarrow 4.11\text{ L}$$

$$(0.658\text{ mole } HNO_3)\left(\frac{2\text{ mole NO}}{8\text{ mole } HNO_3}\right)\left(\frac{22.4\text{ L}}{1\text{ mole}}\right) = 3.6848 \rightarrow 3.68\text{ L}$$

$\boxed{3.68\text{ L can form}}$ (Zn is excess, HNO_3 is limiting)

d. If these amounts (in part c) are allowed to react, but only 3.27 liters of NO are collected, what was the percent yield?

$$\%\text{yield} = \frac{\text{actual}}{\text{expected}} \times 100 = \frac{3.27\text{ L}}{3.6848\text{ L}} \times 100 = 88.743 \rightarrow \boxed{88.7\%}$$

e. If these amounts (in part c) are allowed to react, what mass of excess reactant will remain, once the limiting reactant has been consumed?

HNO_3 was limiting (is all consumed)

$$(0.658\text{ mole } HNO_3)\left(\frac{3\text{ mole Zn}}{8\text{ mole } HNO_3}\right)\left(\frac{65.38\text{ g}}{1\text{ mole}}\right) = 16.1325 \rightarrow 16.1\text{ g}$$

16.1 g Zn will be consumed in the rxn.

we started w/ 18.0 g Zn.

$18.0\text{ g} - 16.1\text{ g} = \boxed{1.9\text{ g Zn remaining after rxn}}$

2. $3\ BaCl_{2\ (aq)} + 2\ Na_3PO_{4\ (aq)} \text{ --------> } Ba_3(PO_4)_{2(s)} + 6\ NaCl_{(aq)}$

If 0.432 moles of barium chloride react are allowed to react with 0.383 moles of sodium phosphate,

a. What mass of barium phosphate should be produced? $Ba_3(PO_4)_2$ has a formula mass of 601.93 amu.

$(0.432 \text{ moles } BaCl_2)\left(\frac{1 \text{ mole } Ba_3(PO_4)_2}{3 \text{ mole } BaCl_2}\right)\left(\frac{601.93\text{ g}}{1 \text{ mole}}\right) = 86.68 \rightarrow 86.7\text{g}$

$(0.383 \text{ moles } Na_3PO_4)\left(\frac{1 \text{ mole } Ba_3(PO_4)_2}{2 \text{ mole } Na_3PO_4}\right)\left(\frac{601.93\text{g}}{1 \text{ mole}}\right) = 115.3 \rightarrow 115\text{g}$

So, 86.7g can form.

or: $\frac{0.432}{0.383} = 1.13$ $\quad 1.13 < \frac{3}{2}$ so $BaCl_2$ is limiting

$(0.432 \text{ moles } BaCl_2)\left(\frac{1 \text{ mole } Ba_3(PO_4)_2}{3 \text{ mole } BaCl_2}\right)\left(\frac{601.93\text{g}}{1 \text{ mole}}\right) = 86.7\text{g } Ba_3(PO_4)_2$

b. Which reactant is the limiting reactant? $BaCl_2$
Which reactant is the excess reactant? Na_3PO_4

c. How many moles of excess reactant should remain after the reaction is complete?

$(0.432 \text{ moles } BaCl_2)\left(\frac{2 \text{ mole } Na_3PO_4}{3 \text{ mole } BaCl_2}\right) =$ 0.288 moles Na_3PO_4 Consumed

0.383 moles Na_3PO_4 @ start
− 0.288 moles Na_3PO_4 consumed

0.095 moles Na_3PO_4 remain

3. $Zn_{(s)} + 2\,HCl_{(aq)} \text{------>} H_{2(g)} + ZnCl_{2(aq)}$

If a 5.68 gram chunk of zinc is dropped into a solution containing 8.22×10^{23} HCl molecules,

a. What mass of hydrogen gas should be collected?

$(5.68\text{ g Zn})\left(\frac{1\text{ mole}}{65.38\text{ g}}\right)\left(\frac{1\text{ mole } H_2}{1\text{ mole Zn}}\right)\left(\frac{2.0158\text{ g}}{1\text{ mole}}\right) = 0.17513 \rightarrow 0.175\text{ g}$

$(8.22\times10^{23}\text{ molecules})\left(\frac{1\text{ mole}}{6.02\times10^{23}\text{ molec}}\right)\left(\frac{1\text{ mole } H_2}{2\text{ mole HCl}}\right)\left(\frac{2.0158\text{ g}}{1\text{ mole}}\right) = 1.38\text{ g}$

so 0.175 g can be collected

OR: $(5.68\text{ g Zn})\left(\frac{1\text{ mole}}{65.38\text{ g}}\right) = 0.08688\text{ moles Zn}$

$\frac{1.37}{.08688} > \frac{2}{1}$

$(8.22\times10^{23}\text{ molecules})\left(\frac{1\text{ mole}}{6.02\times10^{23}\text{ molecules}}\right) = 1.37\text{ mole HCl}$

so HCl is xs
Zn is limiting.
so only use Zn to calculate H_2

b. What volume of hydrogen gas should be collected, if measured at STP?

$(5.68\text{ g Zn})\left(\frac{1\text{ mole}}{65.38\text{ g}}\right)\left(\frac{1\text{ mole } H_2}{1\text{ mole Zn}}\right)\left(\frac{22.4\text{ L}}{1\text{ mole}}\right) = 1.95\text{ L } H_2\text{ gas}$

c. How much excess reactant remains?
(if Zinc is excess, report your answer in grams. Otherwise, report it in molecules.)

(Zn is limiting, HCl is xs)

$(5.68\text{ g Zn})\left(\frac{1\text{ mole}}{65.38\text{ g}}\right)\left(\frac{2\text{ mole HCl}}{1\text{ mole Zn}}\right)\left(\frac{6.02\times10^{23}\text{ molecules}}{1\text{ mole}}\right) = 1.046\times10^{23}$ molec. consumed

8.22×10^{23} @ start $- 1.046\times10^{23}$ consumed $= 7.17\times10^{23}$ molecules remain