Stoichiometry Practice Problems:

Reaction: $2\ H_3PO_4 + 3\ Zn \longrightarrow Zn_3(PO_4)_2 + 3\ H_2$

1a. If 30. grams of zinc react, what mass of zinc phosphate can form?

$$(30.\ g\ Zn)\left(\frac{1\ mole}{65.38 g}\right)\left(\frac{1\ mole\ Zn_3(PO_4)_2}{3\ moles\ Zn}\right)\left(\frac{386.08272 g}{mole}\right) = 59.052 g \rightarrow \boxed{59 g}$$

b. A solution contains 9.0 x 10^{22} molecules of phosphoric acid. What mass of zinc can react with this solution?

$$(9.0 \times 10^{22}\ H_3PO_4\ molecules)\left(\frac{1\ mole}{6.02 \times 10^{23}\ molecules}\right)\left(\frac{3\ moles\ Zn}{2\ moles\ H_3PO_4}\right)\left(\frac{65.38 g}{mole}\right) = 14.66 g \rightarrow \boxed{15 g\ Zn}$$

c. How many moles of zinc can react with 2.4 moles of phosphoric acid?

$$(2.4\ moles\ H_3PO_4)\left(\frac{3\ moles\ Zn}{2\ moles\ H_3PO_4}\right) = \boxed{3.6\ moles\ Zn}$$

d. What mass of hydrogen gas can form, if 0.222 moles of phosphoric acid react?

$$(0.222\ moles\ H_3PO_4)\left(\frac{3\ moles\ H_2}{2\ moles\ H_3PO_4}\right)\left(\frac{2(1.0079 g)\ H_2}{mole}\right) = 0.67126 g\ H_2 \rightarrow \boxed{0.671 g\ H_2}$$

e. How many Zinc atoms must react in order to form 100. grams of zinc phosphate?

$$(100.\ g\ Zn_3(PO_4)_2)\left(\frac{1\ mole}{386.08272 g}\right)\left(\frac{3\ moles\ Zn}{1\ mole\ Zn_3(PO_4)_2}\right)\left(\frac{6.02 \times 10^{23}\ molecules}{1\ mole}\right)$$

$$= 4.67775 \times 10^{23} \rightarrow \boxed{4.68 \times 10^{23}\ Zn\ atoms}$$

2a. If 3.00 x 10^{23} phosphoric acid molecules are allowed to react with 3.44 grams of zinc, how many moles of zinc phosphate can form? Identify the limiting and excess reactants.

$$(3.00 \times 10^{23}\ H_3PO_4\ molecules)\left(\frac{1\ mole}{6.02 \times 10^{23}\ molecules}\right)\left(\frac{1\ mole\ Zn_3(PO_4)_2}{2\ moles\ H_3PO_4}\right) = 0.249\ moles\ (.249169)$$

$$(3.44 g\ Zn)\left(\frac{1\ mole}{65.38 g}\right)\left(\frac{1\ mole\ Zn_3(PO_4)_2}{3\ moles\ Zn}\right) = \boxed{0.0175\ moles\ Zn_3(PO_4)_2}$$

(0.017538)

$0.249 > 0.0175\ \therefore\ H_3PO_4$ was excess and Zn was limiting

b. Suppose that in lab, 0.0169 moles zinc phosphate were collected when the reaction in (a) was done. Calculate the percent yield for the experiment.

$$\%\ yield = \frac{lab}{expected} \times 100 = \frac{0.0169\ moles}{0.017538\ moles} \times 100 = 96.362 \rightarrow \boxed{96.4\%\ yield}$$

Reaction: $2\ H_3PO_4 + 3\ Zn \longrightarrow Zn_3(PO_4)_2 + 3\ H_2$

3. If 0.323 moles of phosphoric acid are allowed to react with 1.2×10^{24} Zn atoms, what mass of hydrogen gas can form? Identify the limiting and excess reactants.

$$\left(0.323 \text{ moles } H_3PO_4\right)\left(\frac{3 \text{ moles } H_2}{2 \text{ moles } H_3PO_4}\right)\left(\frac{2(1.0079g)}{\text{mole}}\right) = 0.976655g \rightarrow \boxed{0.977g}$$

$$\left(1.2 \times 10^{24} \text{ Zn atoms}\right)\left(\frac{1 \text{ mole}}{6.02 \times 10^{23} \text{ atoms}}\right)\left(\frac{3 \text{ moles } H_2}{3 \text{ moles Zn}}\right)\left(\frac{2(1.0079g)}{\text{mole}}\right) = 4.0182g$$

4.0182g > 0.9767g ∴ Zn was excess and H_3PO_4 was limiting

4. If 10.0 grams of phosphoric acid are allowed to react with 0.888 moles of Zn, how many molecules of hydrogen gas can form? Identify the limiting and excess reactants.

$\boxed{9.21 \times 10^{22} \text{ molecules}}$

$$\left(10.0g\ H_3PO_4\right)\left(\frac{1 \text{ mole}}{97.99506g}\right)\left(\frac{3 \text{ moles } H_2}{2 \text{ moles } H_3PO_4}\right)\left(\frac{6.02 \times 10^{23} \text{ molecules}}{\text{mole}}\right) = 9.2148 \times 10^{22}$$

$$\left(0.888 \text{ moles Zn}\right)\left(\frac{3 \text{ moles } H_2}{3 \text{ moles Zn}}\right)\left(\frac{6.02 \times 10^{23} \text{ molecules}}{\text{mole}}\right) = 5.35 \times 10^{23} \text{ molecules}$$

(5.34576×10^{23})

$5.35 \times 10^{23} > 9.21 \times 10^{22}$ ∴ Zn was excess, H_3PO_4 was limiting

Solutions Practice Problems:

5. Identify the solute(s) and the solvent in each of these solutions:

	Solute(s)	solvent
a. A solution containing 175 g water and 250 grams salt.	salt	water
b. A solution containing 175 g water and 250 g liquid propanol	water	propanol
c. $MgSO_{4(aq)}$	$MgSO_4$	water
d. A mixture of gases containing 4 grams methane, 40 grams helium, and 400 grams of neon.	methane, helium	neon
e. Gasoline that contains 80 mL C_8H_{18} per 30 mL C_7H_{16}.	C_7H_{16}	C_8H_{18}
f. $AlCl_{3(aq)}$	$AlCl_3$	water

$Li^{+1} / SO_4^{-2} \rightarrow Li_2SO_4$

6. A solution was made by dissolving 78 grams of lithium sulfate into 389 mL of water. The total solution volume after dissolving was 421 mL.

a. Calculate the concentration of lithium sulfate in this solution.

$$(78g\ Li_2SO_4)\left(\frac{1\,mole}{109.9436g}\right) = 0.70945\ moles\ Li_2SO_4$$

$$(421\,mL)\left(\frac{1L}{1000mL}\right) = 0.421\ L$$

$$\text{molarity} = \frac{\text{moles solute}}{\text{Liters soln.}} = \frac{0.70945\ moles}{0.421L} = 1.6852 \rightarrow \boxed{1.7\ M}$$

b. If you needed to make 500. mL of 0.444 Molar lithium sulfate, what mass of lithium sulfate would you need to use?

$$(0.500L)\left(\frac{0.444\ moles}{1\ Liter}\right)\left(\frac{109.9436g}{1\,mole}\right) = \boxed{24.4\ grams\ Li_2SO_4}$$

OR

$$0.444\ \frac{mole}{L} = \frac{x}{0.500L}$$

$$x = (.500L)(.444\ \tfrac{mole}{L}) = 0.222\ moles$$

$$(0.222\ moles)\left(\frac{109.9436g}{mole}\right) = \boxed{24.4\ grams}$$

c. Another solution has a volume of 750 mL, and contains 0.49 moles of lithium sulfate. Calculate the molarity of this solution.

$$\frac{0.49\ moles}{0.75\ L} = 0.6533 \rightarrow \boxed{0.65\ M}$$

0.80 M

d. If you have 2000. mL of lithium sulfate solution, and you heat the solution up in order to evaporate the water, what mass of solid lithium sulfate would remain?

$$(2000\ L)\left(\frac{0.80\ mole}{L}\right)\left(\frac{109.9436g}{mole}\right) = 175.9\ grams$$

$$\boxed{180\ grams}$$

7. An experiment is done to determine the concentration of a solution hydrochloric acid (HCl). A solution of HClis added to a beaker containing solid calcium carbonate. The HCl and calcium carbonate are allowed to react for two days, and the following data table is obtained:

Volume of HCl(aq) solution: 275 mL
Mass of beaker and CaCO3 (before the reaction): 84.67 g
Mass of beaker and remaining CaCO3 (after the reaction.): 72.89 g

a. Write the balanced reaction (with subscripts) that occurs between the HCl solution and the calcium carbonate.

$2HCl_{(aq)} + CaCO_{3(s)} \rightarrow CaCl_{2(aq)} + H_2O_{(l)} + CO_{2(g)}$

b. Calculate the molarity of the hydrochloric acid.

84.67 g − 72.89 g = 11.78 g $CaCO_3$ consumed in the rxn.

$$(11.78 g\ CaCO_3)\left(\frac{1 mole}{100.0872 g}\right)\left(\frac{2 mole\ HCl}{1 mole\ CaCO_3}\right) = 0.235395\ moles\ HCl$$

$$\frac{0.235395\ moles}{0.275\ L} = 0.85599 \rightarrow \boxed{0.856\ M}$$

(Idk why the key says 0.860?)

8. An experiment is done to determine the concentration of a solution of sodium phosphate. 150. mL of the "unknown molarity" sodium phosphate solution are mixed with an excess of zinc chloride solution, and a white precipitate forms. The precipitate is filtered, washed, and dried in the oven. 11.4 grams of precipitate were formed in the reaction.

a. Complete the reaction that occurred (balance and do phase subscripts):

$2Na_3PO_{4(aq)} + 3ZnCl_{2(aq)}$ ------> $6NaCl_{(aq)} + Zn_3(PO_4)_{2(s)}$

b. Which substance was the precipitate? $\boxed{Zn_3(PO_4)_2}$ (the solid)

c. Based on the mass of precipitate that formed, used stoichiometry to calculate the moles of sodium phosphate that were in the sodium phospate solution.

$$(11.4 g\ Zn_3(PO_4)_2)\left(\frac{1 mole}{386.0827 g}\right)\left(\frac{2 mole\ Na_3PO_4}{1 mole\ Zn_3(PO_4)_2}\right)$$

$$= 0.059055 \rightarrow \boxed{0.0591\ moles}$$

d. Calculate the molarity of the sodium phosphate solution.

$$\frac{0.059055\ moles}{0.150\ L} = 0.393698 \rightarrow \boxed{0.394\ M}$$

9. Pure potassium dichromate, $K_2Cr_2O_7$, is an orange solid at room temperature. It dissolves into water to make an orange colored solution. Suppose that you have two solutions of potassium chromate dissolved in water.
"Solution 1" contains 0.118 moles of potassium dichromate, and has a volume of 200. mL.
"Solution 2" contains 0.257 moles of potassium dichromate, and has a volume of 750. mL.
"Solution 3" contains 0.348 moles of potassium dichromate, and has a volume of 650. mL.

a. What color would you expect the solutions to absorb the most strongly? explain.

Blue. Blue and orange are complementary colors, so if the solution absorbs blue light most strongly, it will appear orange.

b. Which of these solutions is more dilute? Solution 2 (it has the lowest molarity; see below)

c. Which of these solutions is the most concentrated? Solution #1 (it had the highest molarity)

Solution 1: $\frac{0.118 \text{ moles}}{0.200 \text{ L}} = 0.590 \text{ M}$

Solution 2: $\frac{0.257 \text{ moles}}{0.750 \text{ L}} = 0.343 \text{ M}$

Solution 3: $\frac{0.348 \text{ moles}}{0.650 \text{ L}} = 0.535 \text{ M}$

d. If a few mL of each solution are placed in a cuvette in a spectrometer, which solution would have the highest absorbance of the color of light you chose in part (a)?

Solution #1. The higher the concentration, the more light it will absorb. (so solution #1 will also be the darkest/deepest orange)

e. If you are going to make 800. mL of 0.300 molar $K_2Cr_2O_7$, what mass of potassium chromate would you need to weigh out?

$$0.300 \text{ M} = \frac{x}{0.800 \text{ L}}$$

$$x = (0.800 \text{ L})(.300 \tfrac{\text{mole}}{\text{L}}) = 0.240 \text{ moles } K_2Cr_2O_7$$

$$(0.240 \text{ moles})\left(\frac{294.1844 \text{ g}}{1 \text{ mole}}\right) = 70.6 \text{ grams}$$