1) A quick, inexpensive source of hydrogen gas is the reaction of zinc with hydrochloric acid (Figure 9). If 0.35 mol of zinc is placed in 0.60 mol of hydrochloric acid,

a) which reactant will be completely consumed? HCl

$$\underset{0.35\,mol}{Zn_{(s)}} + \underset{0.60\,mol}{2HCl_{(aq)}} \rightarrow H_{2(g)} + ZnCl_{2(aq)}$$

$$n_{Zn(from\ HCl)} = 0.60\,mol \times \frac{1}{2} = 0.30\,mol$$ - Too much Zn. Zn in excess.

b) what mass of the other reactant will remain after the reaction is complete?

$$n_{Zn(left)} = \underset{(start)}{0.35\,mol} - \underset{(used)}{0.30\,mol} = 0.05\,mol$$

$$m_{Zn(left)} = 0.05\,mol \times \frac{65.41\,g}{mol} = 3.27\,g = \boxed{3\,g}$$

2) A chemical technician is planning to react 3.50 g of lead(II) nitrate with excess potassium bromide in solution.

a) What would be a reasonable mass of potassium bromide to use in this reaction?

$$\underset{\substack{3.50\,g \\ 331.2\,g/mol}}{Pb(NO_3)_{2(aq)}} + \underset{\substack{m=? \\ 119.00\,g/mol}}{2KBr_{(aq)}} \rightarrow 2KNO_{3(aq)} + PbBr_{2(s)}$$

$$m_{KBr} = 3.50\,g \times \frac{1\,mol}{331.2\,g} \times \frac{2}{1} \times \frac{119.00\,g}{mol} = 2.52\,g$$

+10%

$$\boxed{= 2.77\,g}$$

b) Predict the mass of precipitate expected.

$$m_{PbBr_2} = 3.50\,g \times \frac{1\,mol}{331.2\,g} \times \frac{1}{1} \times \frac{367.0\,g}{mol} = \boxed{3.88\,g}$$

3) In a chemical analysis, 3.40 g of silver nitrate in solution reacted with excess sodium chloride to produce 2.81 g of precipitate. What is the percent yield?

$$\underset{\substack{3.40\,g \\ 169.88\,g/mol}}{AgNO_{3(aq)}} + NaCl_{(aq)} \rightarrow \underset{\substack{2.81\,g \\ 143.32\,g/mol}}{AgCl_{(s)}} + NaNO_{3(aq)}$$

$$m_{AgCl} = 3.40\,g \times \frac{1\,mol}{169.88\,g} \times \frac{1}{1} \times \frac{143.32\,g}{mol} = 2.87\,g\ (expected)$$

$$\%\ yield = \frac{actual}{expected} \times 100\% = \frac{2.81\,g}{2.87\,g} \times 100\% = \boxed{98.0\%}$$

4) A solution containing 9.8g of barium chloride is mixed with a solution containing 5.1g of sodium sulfate.

a) Which reactant is in excess?

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$$\underset{\substack{9.8\,g \\ 208.23\,g/mol}}{BaCl_{2(aq)}} + \underset{\substack{5.1\,g \\ 142.05\,g/mol}}{Na_2SO_{4(aq)}} \rightarrow BaSO_{4(s)} + 2NaCl_{(aq)}$$

Excess

$$n_{BaCl_2} = 9.8\,g \times \frac{1\,mol}{208.23\,g} = \boxed{0.047\,mol}$$

$$n_{Na_2SO_4} = 5.1\,g \times \frac{1\,mol}{142.05\,g} = \boxed{0.036\,mol}$$ Limiting.

b) Determine the excess mass.

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$$m_{BaCl_2(left)} = (0.047\,mol - 0.036\,mol) \times \frac{142.05\,g}{mol} = \boxed{1.6\,g}$$

c) Predict the mass of precipitate.

$$m_{BaSO_4} = 0.036\,mol \times \frac{1}{1} \times \frac{233.40\,g}{mol} = \boxed{8.4\,g}$$

5) A technical college instructor wishes a first-year chemistry group to perform an investigation to practise precipitation and filtration techniques and to calculate a percent yield. The class will react 50.00 mL pipetted samples of 0.200 mol/L potassium phosphate solution with an ~~excess of~~ 0.120 mol/L lead(II) nitrate solution.

a) Which reagent is intended to be the limiting reagent? K_3PO_4

$$2\,K_3PO_{4(aq)} + 3Pb(NO_3)_{2(aq)} \rightarrow 6\,KNO_{3(aq)} + Pb_3(PO_4)_{2(s)}$$

K_3PO_4: 50.00 mL, 0.200 mol/L

$Pb(NO_3)_2$: 0.120 mol/L, V = ??

b) What is the minimum volume of lead(II) nitrate solution required?

$$V_{Pb(NO_3)_2} = \frac{0.200\,mol}{L} \times 50.00\,mL \times \frac{1\,L}{0.120\,mol} = \boxed{16.7\,mL}$$

c) What volume of lead(II) nitrate solution should the instructor tell the students to use?

$$V_{Pb(NO_3)_2} = 16.7\,mL + 10\% = 16.7 \times 1.1 = \boxed{18.3\,mL}$$

d) Describe how the students can test for completeness of reaction of the limiting reagent.

See Notes. Multiple Answers.