NS B1 Solution Stoichiometry Sample

Name_____Per____

Combining aqueous solutions to produce a precipitate and making quantitative predictions.

Assume the reaction goes to completion when 35.0 ml of a 0.27 M solution of copper(II) nitrate is combined with 25.0 ml of 0.36 M sodium hydroxide solution. Assuming the volumes are additive, we can write an overall reaction and then calculate several items:

(A) calculate the mass of the precipitate that should form.

(B) If 0.38 g of precipitate did form in the laboratory, calculate the % yield.

(C) Determine the concentration (molarity) of each ion still in the solution.

overall: $Cu(NO_3)_2 + 2\ NaOH \rightarrow Cu(OH)_{2\ (ppt)} + 2\ NaNO_3$

Change both reactants to millimole quantities

0.27 M × 35 ml = **9.45 millimoles $Cu(NO_3)_2$** 0.36 M × 25 ml = **9 millimoles of NaOH**

(A) Use the coefficients to determine which limits: $\frac{9.45\,mmol Cu(NO_3)_2}{1} > \frac{9\,mmol NaOH}{2}$

*Thus the **sodium hydroxide limits** then calculate the mass of ppt that can form*

$$0.009\,mol NaOH \times \frac{1\,mol Cu(OH)_2}{2\,NaOH} \times \frac{97.57\,g}{1\,mol} = 0.439\,g Cu(OH)_2$$

(B) *Determine the % yield* $\frac{0.38\,g Experimental}{0.439\,g Theoretical} \times 100 = 86.6\%\,yield$

(C) *To determine the amount of ions left in solution,*

*First, realize that we will assume that there will be **no hydroxide ions left in solution** since they are the limiting reactant. Then determine the amount of **spectator ions** that will be floating in the solution*

$$9.45\,mmol Cu(NO_3)_2 \times \frac{2\,NO_3^-}{1\,Cu(NO_3)_2} = 18.9\,mmol\ NO_3^- \qquad \frac{18.9\,mmol NO_3^-}{60\,ml} = 0.315\,M\ NO_3^-$$

$$9\,mmol NaOH \times \frac{OH^-}{1\,NaOH} = 9\,mmol\ OH^- \qquad \frac{9\,mmol OH^-}{60\,ml} = 0.15\,M\ OH^-$$

Then determine the moles of copper ions that are needed to go with the limiting hydroxide ions by "doing stoichiometry"

$$9\,mmol NaOH \times \frac{1\,OH^-}{1\,NaOH} \times \frac{1\,Cu^{2+}}{2\,OH^-} = 4.5\,mmol\ Cu^{2+}\ needed\ for\ reaction$$

then calculate the amount of copper ion that will be left over

Thus 9.45 mmol Cu^{2+}started with – 4.5 moles of Cu^{2+} needed = 4.95 mmol Cu^{2+} left over and then calculate molarity

$$\frac{4.95\,mmol Cu^{2+}}{60\,ml(total)} = 0.0825\,M\ Cu^{2+} LeftOver$$

P B1 Solution Stoichiometry Practice Problem

Name_____Per____

Show your work clearly in the space below.

Assume the reaction goes to completion, and the volumes are additive, when 45.0 ml of a 0.54 M solution of barium nitrate is combined with 35.0 ml of 0.54 M sodium phosphate solution,

(A) calculate the mass of the precipitate that should form.

(B) If 3.32 g of precipitate did form in the laboratory, calculate the % yield.

(C) Determine the concentration (molarity) of each ion still floating in the solution.

2. molecular: $3\ Ba(NO_3)_2 + 2\ Na_3PO_4 \rightarrow Ba_3(PO_4)_{2\ (ppt)} + 6\ NaNO_3$

   net ionic: $3\ Ba^{2+} + 2\ PO_4^{3-} \rightarrow Ba_3(PO_4)_{2\ (ppt)}$

   change both reactants to mole quantities

   (45 ml)(0.54 M) = 24.3 mmol $Ba(NO_3)_2$ (35 ml)(0.54 M) = 18.9 mmol of Na_3PO_4

   a. *determine that the barium nitrate limits then calculate the mass of ppt that can form*

   $24.3 mmol Ba(NO_3)_2 \times \left(\frac{1 Ba_3(PO_4)_2}{3 Ba(NO_3)_2} \right)$ = 8.1 mmol of $Ba_3(PO_4)_{2\ (ppt)}$ can be formed $\times \left(\frac{602 g}{1 mol} \right)$ = **4,880 mg (4.88 g) of ppt**

   b. *determine the % yield*

   $\left(\frac{3.32 g Experimental}{4.88 g Theoretical} \right) \times 100 = 68.1\%$

c. *To determine the amount of ions left in solution,*

first, realize that we will assume there will be ***no barium ions left in solution*** *since they are the limiting reactant.*

Then determine the amount of ***spectator ions*** *that will be floating in the solution*

$24.3 mmol Ba(NO_3)_2 \times \left(\frac{2 NO_3^-}{1 Ba(NO_3)_2}\right)$ = 48.6 mmol NO_3^-, next calculate molarity $\left(\frac{48.6 mmol NO_3^-}{80 ml (totalVol)}\right)$ = **0.61 M NO_3^-**

$18.9 mmol Na_3PO_4 \times \left(\frac{3 Na^+}{1 Na_3PO_4}\right)$ = 56.7 mmol Na^+ ions, next calculate molarity $\left(\frac{56.7 mmol Na^+}{80 ml (totalVol)}\right)$ = **0.71 M Na^+**

Then determine the moles of phosphate that are needed to go with the limiting reactant by "doing stoichiometry"

$24.3 mmol Ba(NO_3)_2 \times \left(\frac{2 Na_3PO_4}{3 Ba(NO_3)_2}\right)$ = 16.2 mmol of Na_3PO_4 = 16.2 mmol PO_4^{3-} required to go with all the Ba^{2+}

then calculate the amount of phosphate ion that will be left over (Phosphate is the excess reactant so "some" of it will remain.)

(18.9 mmol of PO_4^{3-} started with) − (16.2 mmol of PO_4^{3-} needed) = 2.7 mmol PO_4^{3-} left over

and then calculate the molarity $\left(\frac{2.7 mmol PO_4^{3-}}{80 ml (totalVol)}\right)$ = **0.034 M PO_4^{3-}**

3. molecular: $2\ AgNO_3 + K_2CrO_4 \rightarrow Ag_2CrO_{4(ppt)} + 2\ KNO_3$

net ionic: $2\ Ag^+ + CrO_4^{2-} \rightarrow Ag_2CrO_{4(ppt)}$

change both reactants to mole quantities

(0.040 L)(0.87 M) = 0.0348 moles $AgNO_3$ (0.055 L)(0.57 M) = 0.03135 moles of K_2CrO_4

a. *determine that the silver nitrate limits then calculate the mass of ppt that can form*

$0.0348 mol AgNO_3 \times \left(\frac{1 Ag_2CrO_4}{2 AgNO_3}\right)$ = 0.0174 moles of $Ag_2CrO_{4(ppt)}$ can be formed $\times \left(\frac{331.8 g}{1 mol}\right)$ = **5.77 g of ppt**

b. *determine the % yield*

$\left(\frac{4.96 g Experimental}{5.77 g Theoretical}\right) \times 100 = 86.0\%$

c. *To determine the amount of ions left in solution,*

first, realize that there will be ***no silver ions left in solution*** *since they are the limiting reactant.*

Then determine the amount of ***spectator ions*** *that will be floating in the solution*

$0.0348 mol AgNO_3 \times \left(\frac{1 NO_3^-}{1 AgNO_3}\right)$ = 0.0348 moles NO_3^-, next calculate molarity $\left(\frac{0.0348 moles NO_3^-}{0.095 L (totalVol)}\right)$ = **0.37 M NO_3^-**

$0.03135 mol K_2CrO_4 \times \left(\frac{2 K^+}{1 K_2CrO_4}\right)$ = 0.0627 moles K^+ ions, next calculate molarity $\left(\frac{0.0627 K^+}{0.095 L (totalVol)}\right)$ = **0.66 M K^+**

Then determine the moles of chromate that are needed to go with the limiting reactant by "doing stoichiometry"

$0.0348 molAgNO_3 \times \left(\frac{1K_2CrO_4}{2AgNO_3} \right)$ = 0.0174 moles of CrO_4^{2-} required to go with all the Ag^+

then calculate the amount of chromate ion that will be left over (Chromate is the excess reactant so "some" of it will remain.)

(0.03135 moles of CrO_4^{2-} started with) − (0.0174 moles of CrO_4^{2-} needed) = 0.01395 moles CrO_4^{2-} left over and then calculate the molarity $\left(\frac{0.01395 molCrO_4^{2-}}{0.095 L(totalVol)} \right)$ = **0.15 M CrO_4^{2-}**

4. molecular: $3\ Sn(NO_3)_2 + 2\ K_3PO_4 \rightarrow Sn_3(PO_4)_{2\ (ppt)} + 6\ KNO_3$

   net ionic: $3\ Sn^{2+} + 2\ PO_4^{3-} \rightarrow Sn_3(PO_4)_{2\ (ppt)}$

   change both reactants to mole quantities

   (35 ml)(0.25 M) = **8.75 mmol $Sn(NO_3)_2$** (45 ml)(0.30 M) = **13.5 mmol of Na_3PO_4**

   a. *determine that the barium nitrate limits then calculate the mass of ppt that can form*

   $8.75 mmolSn(NO_3)_2 \times \left(\frac{1Ba_3(PO_4)_2}{3Sn(NO_3)_2} \right)$ = 2.91 mmol of $Sn_3(PO_4)_{2\ (ppt)}$ can be formed $\times \left(\frac{546g}{1mol} \right)$ = **1.59 g of ppt**

   b. *determine the % yield*

   $\left(\frac{1.00 gExperimental}{1.59 gTheoretical} \right) \times 100 = 62.9\%$

   c. *To determine the amount of ions left in solution,*

   first, realize that we will assume there will be ***no barium ions left in solution*** *since they are the limiting reactant.*

   Then determine the amount of ***spectator ions*** *that will be floating in the solution*

   $8.75 mmolSn(NO_3)_2 \times \left(\frac{2NO_3^-}{1Sn(NO_3)_2} \right)$ = 17.5moles NO_3^-, next calculate molarity $\left(\frac{17.5 molesNO_3^-}{80 mL(totalVol)} \right)$ = **0.219 M NO_3^-**

   $13.5 molK_3PO_4 \times \left(\frac{3Na^+}{1Na_3PO_4} \right)$ = 40.5moles Na^+ ions, next calculate molarity $\left(\frac{40.5 Na^+}{80 mL(totalVol)} \right)$ = **0.506 M Na^+**

   Then determine the moles of phosphate that are needed to go with the limiting reactant by "doing stoichiometry"

   $13.5 mmolSn(NO_3)_2 \times \left(\frac{2K_3PO_4}{3Sn(NO_3)_2} \right)$ = 9.0 mmol of K_3PO_4 = 9.0 mmol of PO_4^{3-} required to go with all the Sn^{2+}

   then calculate the amount of phosphate ion that will be left over (Phosphate is the excess reactant so "some" of it will remain.)

   (13.5 mmoles of PO_4^{3-} started with) − (9.0 mmoles of PO_4^{3-} needed) = 4.5 mmol PO_4^{3-} left over and then calculate the molarity $\left(\frac{4.5 mmolPO_4^{3-}}{80 mL(totalVol)} \right)$ = **0.056 M PO_4^{3-}**

5. molecular: $CoCl_2 + K_2CO_3 \rightarrow CoCO_{3\,(ppt)} + 2\,KCl$
   net ionic $Co^{2+} + CO_3^{2-} \rightarrow CoCO_{3\,(ppt)}$
   the mass of precipitate will determine the original molarity of the potassium chromate solution

   $8.11g\left(\frac{1mol}{118.9g}\right)$ = 0.0682 mol of ppt which is the same mol of K_2CO_3 because of the 1:1 ratio

   $\left(\frac{0.0682molK_2CO_3}{0.035L(totalVol)}\right)$ = **1.95 M of K_2CO_3 solution**

6. molecular: $2\,AlCl_3 + 3\,K_2CrO_4 \rightarrow Al_2(CrO_4)_{3\,(ppt)} + 6\,KCl$
   net ionic: $2\,Al^{3+} + 3\,CrO_4^{2-} \rightarrow Al_2(CrO_4)_{3\,(ppt)}$
   the mass of precipitate will determine the original molarity of the potassium chromate solution

   $1.54g\left(\frac{1mol}{402g}\right)$ = 0.00383 mol ppt $\times\left(\frac{3K_2CrO_4}{1Al_2(CrO_4)_3}\right)$ = 0.0115 mol of K_2CrO_4

   $\left(\frac{0.0115molK_2CrO_4}{0.015L(totalVol)}\right)$ = **0.77 M of K_2CrO_4 solution**

7. molecular: $2\,CoCl_2 + K_4Fe(CN)_6 \rightarrow Co_2Fe(CN)_{6\,(ppt)} + 4\,KCl$
   net ionic: $2\,Co^{2+} + Fe(CN)_6^{4-} \rightarrow Co_2Fe(CN)_{6\,(ppt)}$
   the mass of precipitate will determine the original volume of the cobalt(II) chloride solution

   $4.37g\left(\frac{1mol}{331g}\right)$ = 0.0132 mol ppt $\times\left(\frac{2CoCl_2}{1Co_2Fe(CN)_6}\right)$ = 0.0264 mol of $CoCl_2$

   $\left(\frac{0.0264molCoCl_2}{0.05M}\right)$ = **0.0528 L of $CoCl_2$ solution, which is 52.8 ml $CoCl_2$ solution**

8. molecular: $CuSO_4 + K_2CrO_4 \rightarrow CuCrO_{4\,(ppt)} + K_2SO_4$
   net ionic: $Cu^{2+} + CrO_4^{2-} \rightarrow CuCrO_{4\,(ppt)}$
   the mass of precipitate will determine the original volume of the copper(II) sulfate solution required

   $12.3g\left(\frac{1mol}{179.55g}\right)$ = 0.0685 mol of ppt of $CuCrO_4$ $\times\left(\frac{1CuSO_4}{1CuCrO_4}\right)$ = 0.0685 mol of $CuSO_4$

   $\left(\frac{0.0685molCuSO_4}{0.64M}\right)$ = **0.107 L of $CuSO_4$ solution, which is 107 ml $CuSO_4$ solution**

9. molecular: $CoCl_2 + K_2CrO_4 \rightarrow CoCrO_{4\,(ppt)} + 2\,KCl$
   net ionic: $Co^{2+} + CrO_4^{2-} \rightarrow CoCrO_{4\,(ppt)}$
   the mass of precipitate will determine the original volume of the cobalt(II) chloride solution

   $3.86g\left(\frac{1mol}{175g}\right)$ = 0.022 moles of $CoCrO_4$ $\times\left(\frac{1K_2CrO_4}{1CoCrO_4}\right)$ = 0.022 moles of K_2CrO_4

   $\left(\frac{0.022molK_2CrO_4}{0.35M}\right)$ = **0.0630 L of K_2CrO_4 solution, which is 63.0 ml K_2CrO_4 solution**