

Write out a balanced equation that represents the combination of the following aqueous salt, and then complete the stoichiometry problem. Write both the molecular equation and the net ionic equation.

- If 25.0 ml of a 0.34 M solution of lead(II) nitrate is combined with 25.0 ml of 0.34 M sodium iodide solution (Assume volumes are additive.),
 - calculate the mass of the precipitate that should form.
 - If 1.50 g of precipitate did form in the laboratory, calculate the % yield.
 - Determine the concentration (molarity) of each ion still floating in the solution.
- 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,
 - calculate the mass of the precipitate that should form.
 - If 3.32 g of precipitate did form in the laboratory, calculate the % yield.
 - Determine the concentration (molarity) of each ion still floating in the solution.
- Assume the reaction goes to completion, and the volumes are additive, when 40.0 ml of 0.87 M solution of silver nitrate is combined with 55.0 ml of 0.57 M of potassium chromate.
 - calculate the mass of precipitate that should form.
 - If 4.96 g of the precipitate forms in the laboratory, calculate the % yield of ppt formed.
 - Determine the concentration (molarity) of each ion still floating in the solution.
- Assume the reaction goes to completion, and the volumes are additive, when 35.0 ml of 0.25 M tin(II) nitrate is combined with 45.0 ml of 0.30 M potassium phosphate.
 - calculate the mass of precipitate that should form.
 - In the lab, the precipitate was washed, dried and massed as 1.00 g, calculate the % yield of ppt formed.
 - Determine the concentration (molarity) of each ion still floating in the solution.
- An excess of cobalt (II) chloride is combined with 35.0 ml of a potassium carbonate solution. Assuming that the reaction goes to completion and 8.11 g of the dried precipitate forms, determine the original molarity of the potassium carbonate solution.
- An excess of 15.0 ml of potassium chromate is combined with an excess of a aluminum chloride solution. Assuming that the reaction goes to completion and 1.54 g of the dried precipitate forms, determine the original molarity of the potassium chromate solution.
- A volume of 0.50 M cobalt (II) chloride is combined with an excess of potassium ferrocyanide solution. Assuming that the reaction goes to completion and 4.37 g of the dried precipitate forms, determine the original volume of the cobalt (II) chloride solution. (NOTE: ferrocyanide ion is $\text{Fe}(\text{CN})_6^{4-}$)
- When 0.64 M solution of copper (II) sulfate solution is combined with an excess of potassium chromate, and 12.3 g of the dried precipitate forms, determine the original volume of the copper (II) sulfate solution used.
- When an excess of cobalt (II) chloride is combined with a 0.35 M solution of potassium chromate, and 3.86 g of the dried precipitate forms, determine the original volume of the potassium chromate solution used.



First, be sure you are working in moles – change both reactants to mole quantities

$$(0.025 \text{ L})(0.34 \text{ M}) = \mathbf{0.0085 \text{ moles Pb}(\text{NO}_3)_2} \quad (0.025 \text{ L})(0.34 \text{ M}) = \mathbf{0.0085 \text{ moles of NaI}}$$

a. determine that the **sodium iodide limits** then calculate the mass of ppt that can form

$$= 0.00425 \text{ moles of PbI}_2(\text{ppt}) \text{ can be formed} \times \left(\frac{461 \text{ g}}{1 \text{ mol}} \right) = \mathbf{1.96 \text{ g of ppt theor}}$$

b. then determine the % yield $0.0085 \text{ mol NaI} \times \left(\frac{1 \text{ PbI}_2}{2 \text{ NaI}} \right)$

$$\left(\frac{1.50 \text{ g Experimental}}{1.96 \text{ g Theoretical}} \right) \times 100 = 76.6\%$$

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

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

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

$$0.0085 \text{ mol Pb}(\text{NO}_3)_2 \times \left(\frac{2 \text{ NO}_3^-}{1 \text{ Pb}(\text{NO}_3)_2} \right) = 0.017 \text{ moles NO}_3^-, \text{ next calculate molarity} \left(\frac{0.017 \text{ moles NO}_3^-}{0.05 \text{ L (total Vol)}} \right) = \mathbf{0.34 \text{ M NO}_3^-}$$

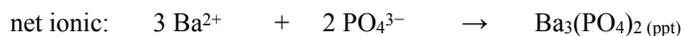
$$0.0085 \text{ mol NaI} \times \left(\frac{1 \text{ Na}^+}{1 \text{ NaI}} \right) = 0.0085 \text{ moles Na}^+ \text{ ions, next calculate molarity} \left(\frac{0.0085 \text{ Na}^+}{0.05 \text{ L (total Vol)}} \right) = \mathbf{0.17 \text{ M Na}^+}$$

Then determine the moles of lead that are needed to go with the limiting reactant by “doing stoichiometry”

$$0.0085 \text{ mol NaI} \times \left(\frac{1 \text{ Pb}(\text{NO}_3)_2}{2 \text{ NaI}} \right) = 0.00425 \text{ moles of Pb}(\text{NO}_3)_2 \text{ required to go with all the I}^- \text{ ions}$$

then calculate the amount of lead ion that will be left over (Lead is the excess reactant so “some” of it will remain.)

Thus (0.0085 moles of Pb^{2+} started with) – (0.00425 moles of Pb^{2+} needed) = 0.00425 moles Pb^{2+} left over and then calculate molarity $\left(\frac{0.00425 \text{ Pb}^{2+}}{0.05 \text{ L (total Vol)}} \right) = \mathbf{0.085 \text{ M Pb}^{2+} \text{ ions remaining in solution.}}$



change both reactants to mole quantities

$$(45 \text{ ml})(0.54 \text{ M}) = 24.3 \text{ mmol Ba}(\text{NO}_3)_2 \quad (35 \text{ ml})(0.54 \text{ M}) = 18.9 \text{ mmol of Na}_3\text{PO}_4$$

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

$$24.3 \text{ mmol Ba}(\text{NO}_3)_2 \times \left(\frac{1 \text{ Ba}_3(\text{PO}_4)_2}{3 \text{ Ba}(\text{NO}_3)_2} \right) = 8.1 \text{ mmol of Ba}_3(\text{PO}_4)_2(\text{ppt}) \text{ can be formed} \times \left(\frac{602 \text{ g}}{1 \text{ mol}} \right) = \mathbf{4,880 \text{ mg (4.88 g) of ppt}}$$

b. determine the % yield

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

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

$$24.3 \text{ mmol Ba(NO}_3)_2 \times \left(\frac{2 \text{ NO}_3^-}{1 \text{ Ba(NO}_3)_2} \right) = 48.6 \text{ mmol NO}_3^-, \text{ next calculate molarity } \left(\frac{48.6 \text{ mmol NO}_3^-}{80 \text{ ml (total Vol)}} \right) = \mathbf{0.61 \text{ M NO}_3^-}$$

$$18.9 \text{ mmol Na}_3\text{PO}_4 \times \left(\frac{3 \text{ Na}^+}{1 \text{ Na}_3\text{PO}_4} \right) = 56.7 \text{ mmol Na}^+ \text{ ions, next calculate molarity } \left(\frac{56.7 \text{ mmol Na}^+}{80 \text{ ml (total Vol)}} \right) = \mathbf{0.71 \text{ M Na}^+}$$

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

$$24.3 \text{ mmol Ba(NO}_3)_2 \times \left(\frac{2 \text{ Na}_3\text{PO}_4}{3 \text{ Ba(NO}_3)_2} \right) = 16.2 \text{ mmol of Na}_3\text{PO}_4 = 16.2 \text{ mmol PO}_4^{3-} \text{ required to go with all the Ba}^{2+}$$

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

$$(18.9 \text{ mmol of PO}_4^{3-} \text{ started with}) - (16.2 \text{ mmol of PO}_4^{3-} \text{ needed}) = 2.7 \text{ mmol PO}_4^{3-} \text{ left over}$$

$$\text{and then calculate the molarity } \left(\frac{2.7 \text{ mmol PO}_4^{3-}}{80 \text{ ml (total Vol)}} \right) = \mathbf{0.034 \text{ M PO}_4^{3-}}$$



change both reactants to mole quantities

$$(0.040 \text{ L})(0.87 \text{ M}) = 0.0348 \text{ moles AgNO}_3 \quad (0.055 \text{ L})(0.57 \text{ M}) = 0.03135 \text{ moles of K}_2\text{CrO}_4$$

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

$$0.0348 \text{ mol AgNO}_3 \times \left(\frac{1 \text{ Ag}_2\text{CrO}_4}{2 \text{ AgNO}_3} \right) = 0.0174 \text{ moles of Ag}_2\text{CrO}_4(\text{ppt}) \text{ can be formed} \times \left(\frac{331.8 \text{ g}}{1 \text{ mol}} \right) = \mathbf{5.77 \text{ g of ppt}}$$

b. determine the % yield

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

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

$$0.0348 \text{ mol AgNO}_3 \times \left(\frac{1 \text{ NO}_3^-}{1 \text{ AgNO}_3} \right) = 0.0348 \text{ moles NO}_3^-, \text{ next calculate molarity } \left(\frac{0.0348 \text{ moles NO}_3^-}{0.095 \text{ L (total Vol)}} \right) = \mathbf{0.37 \text{ M NO}_3^-}$$

$$0.03135 \text{ mol K}_2\text{CrO}_4 \times \left(\frac{2 \text{ K}^+}{1 \text{ K}_2\text{CrO}_4} \right) = 0.0627 \text{ moles K}^+ \text{ ions, next calculate molarity } \left(\frac{0.0627 \text{ K}^+}{0.095 \text{ L (total Vol)}} \right) = \mathbf{0.66 \text{ M K}^+}$$

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

$$0.0348 \text{ mol AgNO}_3 \times \left(\frac{1 \text{ K}_2\text{CrO}_4}{2 \text{ AgNO}_3} \right) = 0.0174 \text{ moles of CrO}_4^{2-} \text{ required to go with all the Ag}^+$$

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

$$\text{calculate the molarity } \left(\frac{0.01395 \text{ mol CrO}_4^{2-}}{0.095 \text{ L (total Vol)}} \right) = \mathbf{0.15 \text{ M CrO}_4^{2-}}$$



change both reactants to mole quantities

$$(35 \text{ ml})(0.25 \text{ M}) = \mathbf{8.75 \text{ mmol Sn(NO}_3)_2} \quad (45 \text{ ml})(0.30 \text{ M}) = \mathbf{13.5 \text{ mmol of Na}_3\text{PO}_4}$$

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

$$8.75 \text{ mmol Sn(NO}_3)_2 \times \left(\frac{1 \text{ Ba}_3(\text{PO}_4)_2}{3 \text{ Sn(NO}_3)_2} \right) = 2.91 \text{ mmol of Sn}_3(\text{PO}_4)_2 \text{ (ppt) can be formed} \times \left(\frac{546 \text{ g}}{1 \text{ mol}} \right) = \mathbf{1.59 \text{ g of ppt}}$$

b. determine the % yield

$$\left(\frac{1.00 \text{ g Experimental}}{1.59 \text{ g Theoretical}} \right) \times 100 = \mathbf{62.9\%}$$

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

$$8.75 \text{ mmol Sn(NO}_3)_2 \times \left(\frac{2 \text{ NO}_3^-}{1 \text{ Sn(NO}_3)_2} \right) = 17.5 \text{ moles NO}_3^-, \text{ next calculate molarity } \left(\frac{17.5 \text{ moles NO}_3^-}{80 \text{ mL (total Vol)}} \right) = \mathbf{0.219 \text{ M NO}_3^-}$$

$$13.5 \text{ mol K}_3\text{PO}_4 \times \left(\frac{3 \text{ Na}^+}{1 \text{ Na}_3\text{PO}_4} \right) = 40.5 \text{ moles Na}^+ \text{ ions, next calculate molarity } \left(\frac{40.5 \text{ Na}^+}{80 \text{ mL (total Vol)}} \right) = \mathbf{0.506 \text{ M Na}^+}$$

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

$$13.5 \text{ mmol Sn(NO}_3)_2 \times \left(\frac{2 \text{ K}_3\text{PO}_4}{3 \text{ Sn(NO}_3)_2} \right) = 9.0 \text{ mmol of K}_3\text{PO}_4 = 9.0 \text{ mmol of PO}_4^{3-} \text{ required to go with all the Sn}^{2+}$$

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

$$\text{molarity } \left(\frac{4.5 \text{ mmol PO}_4^{3-}}{80 \text{ mL (total Vol)}} \right) = \mathbf{0.056 \text{ M PO}_4^{3-}}$$



the mass of precipitate will determine the original molarity of the potassium chromate solution

$$8.11 \text{g} \left(\frac{1 \text{mol}}{118.9 \text{g}} \right) = 0.0682 \text{ mol of ppt which is the same mol of } \text{K}_2\text{CO}_3 \text{ because of the 1:1 ratio}$$

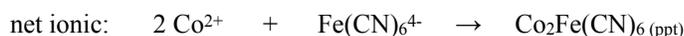
$$\left(\frac{0.0682 \text{molK}_2\text{CO}_3}{0.035 \text{L}(\text{totalVol})} \right) = \mathbf{1.95 \text{ M of K}_2\text{CO}_3 \text{ solution}}$$



the mass of precipitate will determine the original molarity of the potassium chromate solution

$$1.54 \text{g} \left(\frac{1 \text{mol}}{402 \text{g}} \right) = 0.00383 \text{ mol ppt} \times \left(\frac{3 \text{K}_2\text{CrO}_4}{1 \text{Al}_2(\text{CrO}_4)_3} \right) = 0.0115 \text{ mol of K}_2\text{CrO}_4$$

$$\left(\frac{0.0115 \text{molK}_2\text{CrO}_4}{0.015 \text{L}(\text{totalVol})} \right) = \mathbf{0.77 \text{ M of K}_2\text{CrO}_4 \text{ solution}}$$



the mass of precipitate will determine the original volume of the cobalt(II) chloride solution

$$4.37 \text{g} \left(\frac{1 \text{mol}}{331 \text{g}} \right) = 0.0132 \text{ mol ppt} \times \left(\frac{2 \text{CoCl}_2}{1 \text{Co}_2\text{Fe}(\text{CN})_6} \right) = 0.0264 \text{ mol of CoCl}_2$$

$$\left(\frac{0.0264 \text{molCoCl}_2}{0.05 \text{M}} \right) = \mathbf{0.0528 \text{ L of CoCl}_2 \text{ solution, which is 52.8 ml CoCl}_2 \text{ solution}}$$



the mass of precipitate will determine the original volume of the copper(II) sulfate solution required

$$12.3 \text{g} \left(\frac{1 \text{mol}}{179.55 \text{g}} \right) = 0.0685 \text{ mol of ppt of CuCrO}_4 \times \left(\frac{1 \text{CuSO}_4}{1 \text{CuCrO}_4} \right) = 0.0685 \text{ mol of CuSO}_4$$

$$\left(\frac{0.0685 \text{molCuSO}_4}{0.64 \text{M}} \right) = \mathbf{0.107 \text{ L of CuSO}_4 \text{ solution, which is 107 ml CuSO}_4 \text{ solution}}$$



the mass of precipitate will determine the original volume of the cobalt(II) chloride solution

$$3.86 \text{g} \left(\frac{1 \text{mol}}{175 \text{g}} \right) = 0.022 \text{ moles of CoCrO}_4 \times \left(\frac{1 \text{K}_2\text{CrO}_4}{1 \text{CoCrO}_4} \right) = 0.022 \text{ moles of K}_2\text{CrO}_4$$

$$\left(\frac{0.022 \text{molK}_2\text{CrO}_4}{0.35 \text{M}} \right) = \mathbf{0.0630 \text{ L of K}_2\text{CrO}_4 \text{ solution, which is 63.0 ml K}_2\text{CrO}_4 \text{ solution}}$$