

Prelaboratory Exercise: Limiting Reagent

Lab Grade

Name: _____

Section: _____

| | | |
|--|--|-----|
| Prelab Questions | | 26 |
| General Format (Signature, ink, no obliterations, etc.) | | 8 |
| Data and Analysis (observations, questions, units, significant figures, sample calculations, etc.) | | 20 |
| Accuracy (% error) | | 20 |
| Post Lab Questions | | 26 |
| Total | | 100 |

1. A student weighs out 1.100 grams of copper(II) chloride dihydrate and 3.500 grams of silver nitrate:

a. Calculate the molar masses for the reactants:

| | $\text{CuCl}_2 \cdot 2\text{H}_2\text{O}$ | AgNO_3 |
|--------------------|---|-----------------|
| Molar Mass (g/mol) | 170.5 | 169.9 |

b. Calculate the moles of copper(II) chloride dihydrate.

$$1.100 \text{ g } \text{CuCl}_2 \cdot 2\text{H}_2\text{O} \left| \frac{1 \text{ mol } \text{CuCl}_2 \cdot 2\text{H}_2\text{O}}{170.5 \text{ g } \text{CuCl}_2 \cdot 2\text{H}_2\text{O}} \right| = 6.4516 \times 10^{-3} \text{ mol } \text{CuCl}_2 \cdot 2\text{H}_2\text{O}$$

c. Calculate the moles of copper(II) chloride from the moles of copper(II) chloride dihydrate.

$$6.4516 \times 10^{-3} \text{ mol } \text{CuCl}_2 \cdot 2\text{H}_2\text{O} \left| \frac{1 \text{ mol } \text{CuCl}_2}{1 \text{ mol } \text{CuCl}_2 \cdot 2\text{H}_2\text{O}} \right| = 6.4516 \times 10^{-3} \text{ mol } \text{CuCl}_2$$

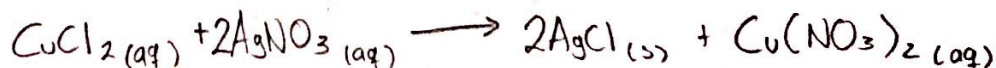
d. What happens to the water of hydration when the solid dissolves?

The water becomes part of the solution

e. Calculate the moles of silver nitrate.

$$3.500 \text{ g } \text{AgNO}_3 \left| \frac{1 \text{ mol } \text{AgNO}_3}{169.9 \text{ g } \text{AgNO}_3} \right| = 0.02060 \text{ mol } \text{AgNO}_3$$

f. Write the balanced chemical equation for the reaction of copper(II) chloride and silver nitrate.



g. Determine the limiting reagent by comparing the theoretical mole ratio to the actual mole ratio:

| Theoretical mole ratio | Actual mole ratio | Limiting Reagent is |
|---|--|---------------------|
| $\frac{1 \text{ mol } \text{CuCl}_2}{2 \text{ mol } \text{AgNO}_3} = 0.5$ | $\frac{6.4516 \times 10^{-3} \text{ mol } \text{CuCl}_2}{0.02060 \text{ mol } \text{AgNO}_3} = 0.31$ | CuCl_2 |

- h. Write the balanced chemical equation for the reaction and complete the table below. Be sure to use the correct number of significant figures. Remember that leading zeros are not considered significant

| | | | | |
|---------------------|---|--|--|---|
| Reaction | $\text{CuCl}_2(\text{aq})$ | $+ 2\text{AgNO}_3(\text{aq})$ | $\rightarrow 2\text{AgCl}(\text{s})$ | $+ \text{Cu}(\text{NO}_3)_2(\text{aq})$ |
| Initial moles | $6.4516 \times 10^{-3} \text{ mol}$ | 0.02060 mol | 0 mol | 0 mol |
| Change moles | $-x$ | $-2x$ | $+2x$ | $+x$ |
| End moles | $6.4516 \times 10^{-3} \text{ moles} - x$ | $0.02060 \text{ moles} - 2x$ | $2x$ | x |
| End moles numerical | 0 mol left | $0.02060 \text{ moles} - 2(6.4516 \times 10^{-3} \text{ moles}) = 7.6968 \times 10^{-3} \text{ mol}$ | $2(6.4516 \times 10^{-3}) = 0.01290 \text{ mol}$ | $6.4516 \times 10^{-3} \text{ mol}$ |

- i. What does x equal?

$$6.4516 \times 10^{-3} - x = 0 \quad \therefore \quad x = 6.4516 \times 10^{-3} \text{ moles}$$

- j. Calculate the molar masses for the products:

| | | |
|--------------------|----------------------------|---------------|
| | $\text{Cu}(\text{NO}_3)_2$ | AgCl |
| Molar Mass (g/mol) | 187.5 | 143.4 |

- k. How many grams of precipitate can be collected?

$$0.01290 \text{ mol AgCl}(\text{s}) \left| \frac{143.4 \text{ g AgCl}(\text{s})}{1 \text{ mol AgCl}(\text{s})} \right| = 1.8499 \text{ g AgCl}(\text{s})$$

- l. If 0.8525 g of silver chloride is collected what is the percent yield?

$$\% \text{ yield} = \frac{0.8525}{1.8499} \times 100\% = 46.08\%$$

- m. How many grams of the excess reagent are left at the end of the reaction?

$$1.2452 \times 10^{-2} \text{ mol AgNO}_3(\text{exc}) \left| \frac{169.9 \text{ g AgNO}_3}{1 \text{ mol AgNO}_3} \right| = 0.2116 \text{ g AgNO}_3(\text{exc})$$

2. Complete the table below:

| | | | | |
|--------------------|--------------------------|---|-----------------|---------------|
| | Na_2CO_3 | $\text{CaCl}_2 \cdot 2\text{H}_2\text{O}$ | CaCO_3 | NaCl |
| Molar Mass (g/mol) | 106 | 147 | 100 | 58.5 |

Data Sheet: Limiting Reagent

TABLE 10.2

| Data | Sample Calculations |
|--|-----------------------------|
| Assigned Letter | |
| Spreadsheet ID | |
| Actual weight of Na_2CO_3 used mass Na_2CO_3 + beaker = | 45.9798 g |
| mass beaker = | 44.9709 g |
| mass Na_2CO_3 = | 1.0089 g |
| Describe the Na_2CO_3 | White granulated solid |
| Actual moles Na_2CO_3 used | 9.5179×10^{-3} mol |
| Actual weight of $\text{CaCl}_2 \cdot 2\text{H}_2\text{O}$ used mass $\text{CaCl}_2 \cdot 2\text{H}_2\text{O}$ + beaker = | 48.2015 g |
| mass beaker = | 46.5511 g |
| mass $\text{CaCl}_2 \cdot 2\text{H}_2\text{O}$ = | 1.6504 g |
| Describe the $\text{CaCl}_2 \cdot 2\text{H}_2\text{O}$ | White solid pellets |
| Actual moles $\text{CaCl}_2 \cdot 2\text{H}_2\text{O}$ used | 0.011226 |
| Actual moles CaCl_2 used | 0.011226 |
| Weight of filter paper | 0.3922 g |
| Weight of watch glass | 1.5107 g |
| Describe the wet CaCO_3 | White and thick |
| Weight of filter paper, watch glass and precipitate 1st drying | 3.4723 g |
| Weight of filter paper, watch glass and precipitate 2nd drying | 3.4003 g |

TABLE 10.3

| | $\text{Na}_2\text{CO}_3(\text{aq})$ | + $\text{CaCl}_2(\text{aq})$ | $\rightarrow \text{CaCO}_3(\text{s})$ | + $2\text{NaCl}(\text{aq})$ |
|---------------------|---|-------------------------------------|---------------------------------------|-----------------------------|
| Initial moles | $9.5179 \times 10^{-3} \text{ mol}$ | 0.011263 mol | 0 | 0 |
| Change moles | $-x$ | $-x$ | $+x$ | $+2x$ |
| End moles | $9.5179 \times 10^{-3} \text{ mol} - x$ | $0.011263 \text{ mol} - x$ | x | $2x$ |
| End moles numerical | 0 | $1.7451 \times 10^{-3} \text{ mol}$ | $9.5179 \times 10^{-3} \text{ mol}$ | 0.01904 mol |

TABLE 10.4

| Theoretical mole ratio | Actual mole ratio | Limiting Reagent is |
|--|--|--------------------------|
| $\frac{1 \text{ mol } \text{CaCl}_2}{1 \text{ mol } \text{Na}_2\text{CO}_3} = 1$ | $\frac{0.011263 \text{ mol } \text{CaCl}_2}{9.5179 \times 10^{-3} \text{ mol } \text{Na}_2\text{CO}_3} = 1.18$ | Na_2CO_3 |

Sample Calculations

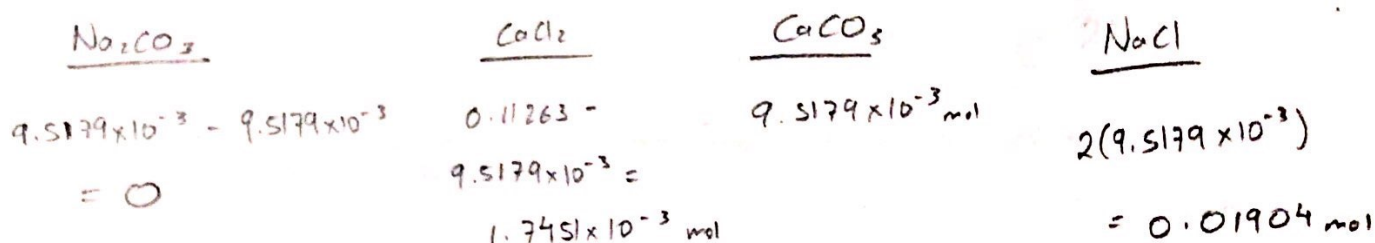


TABLE 10.5

| Results | |
|--|--------------|
| Theoretical weight of CaCO_3 | 0.9527 g |
| Actual weight of CaCO_3 collected | 1.4974 g |
| Describe the dried CaCO_3 | White powder |
| Percent Yield | 157% |

Sample Calculations

$$9.5179 \times 10^{-3} \text{ mol } \text{CaCO}_3 \left| \frac{100.1 \text{ g } \text{CaCO}_3}{1 \text{ mol } \text{CaCO}_3} \right. = 0.9527 \text{ g } \text{CaCO}_3$$

$$3.4003 \text{ g} - 0.3922 \text{ g} - 1.5107 \text{ g} = 1.4974 \text{ g}$$

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$$\% \text{ yield} = \frac{1.4974 \text{ g}}{0.9527 \text{ g}} \times 100\% = 157\%$$

Chemistry 120 Grossmont College

Post Lab Questions

i. Describe the effect on the actual yield and percent yield (increase, decrease, or no change), if the following errors occurred. Be sure to explain your reasoning.

a. The filter paper was still wet when the final product was weighed.

The mass would have been higher, so the % yield would be higher too.

b. Some product fell through the filter paper and was seen in the filter flask during the vacuum filtration.

The mass would have diminished, so the % yield would be lower.

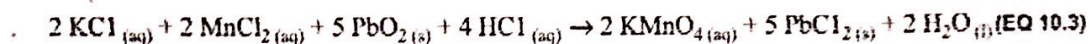
c. Some product fell on the floor and was scraped up with some dust particles, and then weighed for the final mass.

Same as part a.

2. What are you to do with unused chemical in the lab?

Put the unused chemicals in a waste container.

3. In the reaction below 25.00 g of MnCl_2 is reacted with 100.0 g of PbO_2 , excess KCl and excess HCl



a. How many grams of KMnO_4 can be produced by this reaction? Use an ICE table.

| Reaction | 2MnCl_2 | 5PbO_2 | 2KMnO_4 |
|---------------------|--|--|--|
| Initial moles | 0.1987 mol | 0.4181 mol | 0 |
| Change moles | $-2x$ | $-5x$ | $+2x$ |
| End moles | $0.1987 - 2x = 0$ $x = 0.09935 \text{ mol}$ | $0.4181 - 5x = 0$ $x = 0.08362 \text{ mol}$ | — |
| End moles numerical | $0.1987 - 2(0.08362)$ $= 0.03146 \text{ mol}$ | 0 | $2(0.08362) =$ 0.1672 mol |

$$\frac{1 \text{ mol MnCl}_2}{125.8 \text{ g MnCl}_2} = 0.1987$$

$$\frac{1 \text{ mol PbO}_2}{239.2 \text{ g PbO}_2} = 0.4181 \text{ mol}$$

$$0.1672 \text{ mol KMnO}_4 \left| \frac{158 \text{ g KMnO}_4}{1 \text{ mol KMnO}_4} \right| = 26.42 \text{ g KMnO}_4$$

b. If 21.42 g of KMnO_4 is actually produced, what is the percent yield?

$$\% \text{ yield} = \frac{21.42 \text{ g}}{26.42 \text{ g}} \times 100\% = 81.07\%$$

c. How many grams of what starting substances will be left over after the reaction?

$$0.0314 \text{ mol MnCl}_2 \left| \frac{125.8 \text{ g MnCl}_2}{1 \text{ mol MnCl}_2} \right| = 3.95 \text{ g MnCl}_2$$

d. How many grams of what starting substance (i.e., MnCl_2 or PbO_2) must be added to the original quantities of reactants so that there will be neither PbO_2 nor MnCl_2 left over after the reaction?

$$0.0314 \text{ mol MnCl}_2 \left| \frac{5 \text{ mol PbO}_2}{2 \text{ mol MnCl}_2} \right| \left| \frac{239.2 \text{ g PbO}_2}{1 \text{ mol PbO}_2} \right| = 18.78 \text{ g PbO}_2 \text{ more to react with the leftover MnCl}_2$$