**Limiting Reagents Lab**

**Safety Precautions:** Wear safety goggles, non-latex gloves, and lab aprons during the activity. Tie back long hair.

**Materials:**

* 25-mL graduated cylinder
* 2 100-mL beakers
* 50-mL graduated cylinder
* plastic spatula
* sodium carbonate (Na2CO3)
* calcium chloride (CaCl2)
* distilled H2O
* 2 pieces of filter paper
* tape
* scale or triple-beam balance
* ring clamp
* funnel
* timer or watch with second hand
* paper towel

**Day 1:**

1. Gather all equipment.
2. Set up the ring clamp with the funnel. Make sure the funnel is high enough so that a 100-mL beaker can fit under it.
3. Use the tape to label the 100-mL beakers “sodium carbonate” and “calcium chloride.”
4. Use the scale to measure out 1.00 g of sodium carbonate into one beaker and 2.00 g of calcium chloride into the other beaker. (Find the mass of the beaker first and subtract the difference).
5. Add 25 mL of distilled water to each beaker. Gently swirl the beakers for 1–2 minutes, until all of the solids are dissolved.
6. Pour the calcium chloride solution **into** the sodium carbonate solution (**Important**: not the other way around). You will see solid calcium carbonate (CaCO3) form. Gently swirl for 30 seconds.
7. Find the mass of the two pieces of filter paper together. Record your answer in question 1 on Data and Analysis page.
8. Fold the pieces of filter paper together to make a cone. Place it into the funnel. Place the empty beaker under the funnel.
9. Swirl the mixture and pour it into the funnel. Add 5 mL of distilled water to the beaker that you just emptied, and then use the spatula to scrape the residue from the sides. Pour this into the funnel.
10. If the filtrate (liquid) in the bottom beaker is cloudy, pour it through the filter paper again. When it is clear, remove the filter paper cone from the funnel and place it on a piece of paper towel. Write your names on the paper towel and give it to the teacher.
11. Pour the filtrate down the sink, and use a test-tube brush and soapy water to clean the equipment.
12. Answer questions 2–4 on the Data and Analysis page.

**Day 2:**

1. Measure the mass of the filter paper containing the dry CaCO3. Be careful not to spill any of the solid CaCO3. Record the mass on question 5 on the Data and Analysis page.
2. Throw the filter paper and CaCO3 into the garbage.
3. Answer questions 6–11 and answer the conclusion question on the Data and Analysis page.

**Data and Analysis**

1. What is the mass of the two pieces of filter paper? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Na2CO3 + CaCl2 → CaCO3 + 2NaCl

The balanced equation above shows the chemical reaction you have just carried out.

1. Write out the chemical reaction in words: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

1. Which of the compounds are aqueous (liquids)? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
2. Which compound is a solid? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
3. What is the mass of the dry, solid CaCO3 and the filter paper?\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
4. What is the mass of the CaCO3 without the filter paper (see your question 1 answer)?

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

1. Which compound is the limiting reagent in this chemical reaction? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
2. Which reactant was there an excess amount of? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**\*Use stoichiometric ratios to answer questions 9 and 10.**

1. How many grams of NaCl should be produced in this reaction? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
2. How many grams of CaCO3 should be produced in this reaction? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
3. What factors could account for the difference between the actual mass of CaCO3 that you measured, compared to the amount that should be produced?

**Conclusion**

How do limiting reagents affect chemical reactions?

**Additional Practice with Limiting Reagents**

1. For the reaction shown below, only 3 grams of carbon are available but there is plenty of oxygen available.

C + O2 → CO2

a. What is the limiting reagent in this reaction? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

b. How many moles of CO2 could be produced? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

c. How many grams of CO2 could be produced? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

1. For the reaction shown below, 64.1 grams of methyl alcohol (CH3OH) are burned in open air.

2 CH3OH + 3O2 → 2CO2 + 4H2O

a. What is the limiting reagent in this reaction? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

b. How many moles of CH3OH are burned? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

c. How many moles of oxygen are used up? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

d. How many grams of H2O are formed? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Answer KEY**

**Data and Analysis**

1. What is the mass of the two pieces of filter paper? Answers will vary.

Na2CO3 + CaCl2 → CaCO3 + 2NaCl

The balanced equation above shows the chemical reaction you have just carried out.

1. Write out the chemical reaction in words: 1 mole of sodium carbonate reacts with 1 mole of calcium chloride to produce 1 mole of calcium carbonate and 2 moles of sodium chloride.
2. Which of the compounds are aqueous (liquids)? Na2CO3, CaCl2, and NaCl
3. Which compound is a solid? CaCO3
4. What is the mass of the dry, solid CaCO3 and the filter paper? *Answers will vary.*
5. What is the mass of the CaCO3 without the filter paper (see your question 1 answer)?

*Answers will vary.*

1. Which compound is the limiting reagent in this chemical reaction? Na2CO3. See below:

Step 1. Find number of moles of each reactant.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| 1 g Na2CO3 | × | 1 mol | = | 0.009 mol Na2CO3 |
| 105.99 g Na2CO3 |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| 2 g CaCl2 | × | 1 mol | = | 0.019 mol CaCl2 |
| 105.99 g CaCl2 |

Step 2. Choose one reactant (it does not matter which) and determine how many moles of the other reactant are necessary to completely react with it.

There are 0.009 mol Na2CO3 and since the mole ratio of the reactants is 1:1, we need at least 0.009 mol CaCl2.

Step 3. Determine the limiting reagent. The calculation above means that we need 0.009 mol of CaCl2 to completely react with the Na2CO3. We have 0.019 mol of CaCl2 and therefore more than enough CaCl2. Therefore, CaCl2 is in excess and Na2CO3 must be the limiting reagent.

1. Which reactant was there an excess amount of? CaCl2

**\*Use stoichiometric ratios to answer questions 9 and 10.**

1. How many grams of NaCl should be produced in this reaction? 1.11 g NaCl

The molar mass of Na2CO3 is 105.99.

The mole ratio of Na2CO3 to NaCl is 1:2.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| 1 g Na2CO3 | × | 1 mol | = | 0.009 mol Na2CO3 |
| 105.99 g |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| 0.009 mol Na2CO3 | × | 2 mol NaCl | = | 0.019 mol NaCl |
| 1 mol Na2CO3 |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| 0.019 mol NaCl | × | 58.44 g | = | 1.11 g NaCl |
| 1 mol NaCl |

1. How many grams of CaCO3 should be produced in this reaction? 1.00 g CaCO3

The mole ratio of Na2CO3 to CaCO3 is 1:1.

Therefore, 0.009 mol CaCO3 should be produced in the reaction, since 0.009 mol of Na2CO3 are available (from question 9).

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| 0.009 mol CaCO3 | × | 110.98 g | = | 1.00 g CaCO3 |
| 1 mol CaCO3 |

1. What factors could account for the difference between the actual mass of CaCO3 that you measured, compared to the amount that should be produced?

Answers will vary; some of the CaCO3 could have been left in the filtrate or the empty beaker; some CaCO3 may have spilled when we were measuring the mass.

**Conclusion**

How do limiting reagents affect chemical reactions?

Limiting reagents affect chemical reactions by determining (limiting) the amounts of products that can be produced.

**Additional Practice with Limiting Reagents**

1. For the reaction shown below, only 6.0 grams of carbon are available but there is plenty of oxygen available.

C + O2 → CO2

1. What is the limiting reagent in this reaction? Carbon is the limiting reagent, since there is an excess of oxygen available.
2. How many moles of CO2 could be produced? 0.5 mol CO2

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| 6.0 g C | × | 1 mol C | = | 0.5 mol C |
| 12.01 g C |

1 mol C will produce 1 mol CO2

Therefore, 0.5 mol C will produce 0.5 mol CO2

1. How many grams of CO2 could be produced? 22.0 g CO2

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| 0.5 mol CO2 | × | 44.01 g CO2  | = | 22.0 g CO2 |
| 1 mol CO2 |

2.0 g limiting reagent, since there is an excess of oxygen available.pen air..d to produce water. There is still some hydrogen

1. For the reaction shown below, 64.1 grams of methyl alcohol (CH3OH) are burned in open air.

2CH3OH + 3O2 → 2CO2 + 4H2O

1. What is the limiting reagent in this reaction? CH3OH is the limiting reagent, since there is an excess of oxygen available in open air.
2. How many moles of CH3OH are burned? 2 mol CH3OH

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| 64.1 g CH3OH | × | 1 mol CH3OH | = | 2 mol CH3OH |
| 32.05 g CH3OH |

1. How many moles of oxygen are used up? 3 mol O2

2 moles of CH3OH uses 3 moles of O2.

1. How many grams of H2O are formed? 72.08 g H2O

2 moles of CH3OH produces 4 mol H2O

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| 4 mol H2O | × | 18.02 g H2O | = | 72.08 g H2O |
| 1 mol H2O |