

CHEM P106

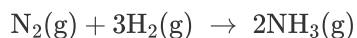
Limiting Reactants

Final Report

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Lesson Limiting Reactants
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Session Spring 2021
Course CHEM P106
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Test Your Knowledge

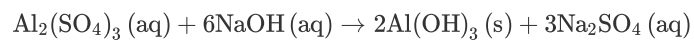
1. Nitrogen and hydrogen react to form ammonia:



Identify the limiting reactant (hydrogen or nitrogen) in each of the following combinations of starting chemicals.

Limiting Reactant: Hydrogen	Limiting Reactant: Nitrogen
1 1.0 mole of nitrogen and 1.0 mole of hydrogen	2 0.75 moles of nitrogen and 2.5 moles of hydrogen
10.0 grams of nitrogen and 10.0 grams of hydrogen	
1.0 mole of nitrogen and 4.0 moles of hydrogen	

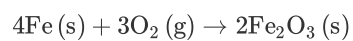
2. Label each type of reaction.



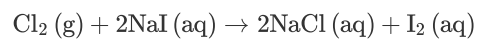
1



2



3



4

3. Move the terms to complete each statement.

A 1 describes a reaction that occurs between two or more chemical substances.

A chemical substance that participates and undergoes change in a chemical reaction is called a

2 .

3 can be used to determine how much of each reactant is needed to produce a specific amount of each product.

The reactant that is consumed first is referred to as the 4 .

The 5 states that the total mass, in a closed system, does not change as the result of reactions between its parts.

Exploration

1. The substances that interact in a reaction are called reactants, while the substances produced from the reaction are called products.

- True
 False

2. The proportion of reactants to products can be calculated using a balanced chemical equation and stoichiometry.

- True
 False

3. A _____ reaction occurs when an uncombined element displaces an element in a compound.

- decomposition
- combination
- single displacement
- double displacement

4. In a chemical reaction, the reactant that is consumed first is referred to as the _____.

- stoichiometry
- smaller reactant
- limiting reactant
- balanced equation
- limiting product

5. In the chemical equation $2\text{Ca} + \text{O}_2 \rightarrow 2\text{CaO}$, if calcium is the limiting reactant, then _____ will be in excess.

- Ca
- O_2
- CaO
- no substances

6. The law of conservation of mass states that _____.

- the total mass, in an open system, does not change as the result of reactions between its parts
- the total mass, in a closed system, does not change as the result of reactions between its parts
- particles at rest tend to stay at rest
- the total energy of an isolated system cannot change

Exercise 1

1. From your calculations, which reaction experiment had closest to stoichiometric quantities? How many moles of NaHCO_3 and $\text{HC}_2\text{H}_3\text{O}_2$ were present in this reaction?

Reaction of acetic acid in test tube #2 and balloon #2. 0.0041667 moles of sodium bicarbonate reacted with 0.004165 moles of 5% acetic acid. The mole ratio was 1:1 of NaHCO_3 : $\text{HC}_2\text{H}_3\text{O}_2$

2. The chemical reaction you investigated is a two-step reaction. What type of reaction occurs in each step? How did you determine your answer?

First step is double displacement while second step is decomposition. In a decomposition reaction, a chemical compound decomposes (breaks down) into two or more individual substances. In a double displacement reaction, two sets of atoms are displaced, forming two new compounds.

3. As the reaction was theoretically performed in a closed system, there should be no change in mass before and after the reaction. What are possible sources of error in your experiment reactions?

1. Air initially in the balloon is not accounted.
2. During the reaction some CO_2 may have leaked through the sides where the balloon is attached with the test tube

4. What is the relationship between the limiting reactant and theoretical yield of CO_2 ?

The yield of CO_2 increases with increase in the molarity of the limiting reactant which is sodium bicarbonate.

5. After the reactions occurred, did the largest balloon size match the largest theoretical yield you calculated in Data Table 4? Use your experimental results to explain your answer. If not, what sources of error do you think caused the discrepancy?

No, because some of CO_2 may have escaped during the experiment hence leading to discrepancy

Data Table 1: Conservation of Mass – Initial Mass

Reaction #	Mass of test tube and 5% HC ₂ H ₃ O ₂ (g) (A)
1	<input type="text" value="3g"/>
2	<input type="text" value="3g"/>
3	<input type="text" value="3g"/>
4	<input type="text" value="3g"/>

Reaction #	Mass of NaHCO ₃ (g) (B)
1	0.10
2	0.20
3	0.35
4	0.50

Reaction #	Mass of balloon and NaHCO ₃ (g) (C)
1	<input type="text" value="2.10g"/>
2	<input type="text" value="2.20g"/>
3	<input type="text" value="2.35g"/>
4	<input type="text" value="2.50g"/>

Reaction #	Total mass before reaction (g) (D = A + C)
1	<input type="text" value="5.10g"/>
2	<input type="text" value="5.20g"/>
3	<input type="text" value="5.35g"/>
4	<input type="text" value="5.50g"/>

Data Table 2: Moles of HC₂H₃O₂

Reaction #	Volume of 5% Vinegar (mL)	Mass of HC ₂ H ₃ O ₂ (g)	Moles of HC ₂ H ₃ O ₂
1	5.0	0.25	0.004165moles
2	5.0	0.25	0.004165moles
3	5.0	0.25	0.004165moles
4	5.0	0.25	0.004165moles

Data Table 3: Moles of NaHCO₃

Reaction #	Mass of NaHCO ₃ (g)	Moles of NaHCO ₃
1	0.10	0.0011905
2	0.20	0.002381
3	0.35	0.0041667
4	0.50	0.005952

Data Table 4: Theoretical Yield of CO₂

Reaction #	Limiting Reactant
1	$NaHCO_3$
2	$NaHCO_3$
3	$HC_2H_3O_2$
4	$HC_2H_3O_2$

Reaction #	Theoretical yield of CO_2 (moles)
1	0.0011905
2	0.002381
3	0.0041667
4	0.005952

Reaction #	Theoretical yield of CO_2 (g)
1	0.052382
2	0.104764
3	0.1833348
4	0.261888

Panel 1: Hypothesis

The law of conservation of mass obeys in a closed syste

Photo 1: Reaction Results

Reaction #	Mass of test tube and 5% of $\text{H}_2\text{C}_2\text{H}_3\text{O}_2$ (A)	Mass of NaHCO_3 (B)	Mass of balloon & NaHCO_3	Total Mass before reaction
1	3g	0.10	2.10g	5.10
2	3g	0.20	2.20g	5.20
3	3g	0.35	2.35g	5.35
4	3g	0.50	2.50g	5.50

TABLE 2: THEORETICAL YIELD OF CO_2

Reaction	Limiting Reagents	Theoretical yield of CO_2 (mole)	Theoretical yield of CO_2 (g)
1	NaHCO_3	0.0011905	0.052382
2	NaHCO_3	0.002381	0.104764
3	$\text{H}_2\text{C}_2\text{H}_3\text{O}_2$	0.0041663	0.183348
4	$\text{H}_2\text{C}_2\text{H}_3\text{O}_2$	0.005552	0.26188

Data Table 5: Conservation of Mass

Reaction #	Total Mass after Reaction (g) (E)	Mass Difference (g) (F = D - E)
1	<input type="text" value="5.05"/>	<input type="text" value="0.5"/>
2	<input type="text" value="5.25"/>	<input type="text" value="0.5"/>
3	<input type="text" value="5.30"/>	<input type="text" value="0.5"/>
4	<input type="text" value="5.45"/>	<input type="text" value="0.5"/>

Competency Review

1. In the chemical equation $4\text{Fe} + 3\text{O}_2 \rightarrow 2\text{Fe}_2\text{O}_3$, 4Fe is considered a _____.

- reactant
- product
- compound

2. Stoichiometry can be applied to a chemical equation to calculate _____.

- the half-life of an element
- significant digits based on SI units
- activation energy in relation to chemical reactivity
- the proportion of reactants and products

3. When chlorine reacts with sodium iodide to form sodium chloride and iodine, a _____ reaction takes place.

- combination
- decomposition
- single displacement
- double displacement

4. Consider a closed system in which aluminum sulfate and sodium hydroxide react to form aluminum hydroxide and sodium sulfate. If aluminum sulfate is the limiting reactant, what other information can be concluded about the substances?

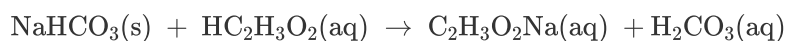
- the reaction rate will decrease
- the sodium hydroxide will be found in excess
- the reverse reaction will be favored
- a single displacement reaction will proceed

5. The law of conservation of mass states that the total mass, in a closed system, does not change as the result of reactions between its parts.

- True
- False

6. The law of conservation of mass states that the total mass in a closed chemical system does not change. In a student experiment, initial mass might differ from final mass due to experimental error.

- True
 False



7. If 0.00416 mols of $\text{HC}_2\text{H}_3\text{O}_2$ are reacted with 0.00595 mols of NaHCO_3 , _____ is/are considered a limiting reactant.

- $\text{HC}_2\text{H}_3\text{O}_2$ and NaHCO_3
 NaHCO_3
 $\text{HC}_2\text{H}_3\text{O}_2$
 the products
 no chemicals

8. Percent yield can be calculated by dividing actual yield by theoretical yield and multiplying by 100.

- True
 False

Extension Questions



a. Determine the volume (mL) of 15.0 M sulfuric acid needed to react with 45.0 g of aluminum to produce aluminum sulfate.

b. Determine the % yield if 112 g of aluminum sulfate is produced under the above conditions.

1. Moles of Aluminium are given by 45g divide by 26 molar mass of aluminium which is equal to 1.7308moles. Mole ratio of aluminium:sulfuric acid is 2:3 respectively and therefore moles of sulfuric acid calculated from the given mole ratio is 2.5962moles. Therefore since 15moles of sulfuric acid are in 1000ml then the volume of sulfuric acid with 2.5962 moles will be 17.308ml.

2. The mole ratio of aluminium to aluminium sulfate is 2:1 respectively, hence by mole ration 0.8654 moles of aluminium sulfate are produced. The 0.8654 moles of aluminium sulfate are equivalent to 294.236g .Thus calculating percentage yield gives us 38.06%