Finding The Limiting Reagent In A Chemical Reaction: Lab Report

1. Introduction

The purpose of this investigation is to gain quantitative information of the reaction that occurs when Sodium iodide and Lead (II) nitrate are combined.

Stoichiometry is the quantitative relation between the number of moles (and therefore mass) of various products and reactants in a chemical reaction (Washington University in St. Louis, 2005.). Chemists use stoichiometry as they are responsible for designing a chemical reaction and analysing the products obtained from it. Chemists must determine the amount of each reactant that is required and the amount of each product that will be produced (Dr. Bailey, n.d.).

The limiting reagent, in a chemical reaction, is the reactant that determines how much of the products are made. The Excess Reagent, in a chemical reaction, is the left-over reactant once the limiting reagent is completely consumed (Khan Academy, 2019). Once all the limiting reagent has been used the reaction cannot continue.

Theoretical yield is the quantity of a product produced from the entire consumption of a limiting reactant in a chemical reaction. It is the amount of product resulting from a perfect (theoretical) chemical reaction (Helmenstine, 2019). Theoretical yield can calculated by first balancing the equation, identifying the limiting reactant, understand the mole ratio and the moles of the products then multiplying the moles in conjunction with the ratio and finally multiply those moles by the molecular weight of each product to get the mass in grams. The actual yield is the amount of the substance that is actually produced in a reaction. It is very unlikely that the actual yield and theoretical yield will be the same, this is due to possible transferring error and or measuring error among others.

In this experiment, the fixed mass of Lead (II) nitrate is being reacted with incremental masses of Sodium iodide. The yellow precipitate (Lead iodide) is used as a measurement for the limiting reagent analysis in the influence of the amount of product that is formed. The prediction of a maximum of 2.31g of Lead iodide can be calculated through the theoretical yield and the balanced chemical equation (refer to equation 1 & 2) shows that the mole ratio of 1:2 is apparent in this equation.

$Pb(NO_3)_2 + 2NaI$ $PbI_2 + 2NaNO_3$ Eq. 2

2. Aim

The aim of this experiment was to conduct a chemical reaction, which created Lead iodide precipitate to be gathered and analysed, and to find the limiting reagent within the reaction.

3. Hypothesis

It can be hypothesised that the limiting reagent of this experiment is Sodium iodide and having a constant of 1.66 grams of Lead (II) nitrate means that the maximum increment of 1.50 grams of Sodium iodide can be reacted to form a theoretical yield of 2.31 grams of Lead iodide. This is because of the Sodium iodide to Lead nitrate and Sodium iodide to Lead iodide mole ratio in the balanced equation is 2 is to 1. Due to this mole ratio it is proven that the maximum amount of reactant and the maximum amount of product with the constant of 1.66 grams of Lead (II) nitrate is 1.50 grams of NaI and 2.31 grams of Lead iodide. (See appendix for calculation).

4. Materials

- 100ml beaker (x 20)
- 100ml conical flask (x 10)
- Filter funnel (x 1)
- Stirring rod (x 1)
- Wash bottle – deionised water (x 1)
- Ethanol – 10ml
- 2-place balance (x 1)
- Oven at 110?C (Fahrenheit)/ 35?C (Degrees)
- Disposable gloves
- Safety glasses
- Lead nitrate – 20 grams
- Sodium iodide – 30 grams

5. Variables

Table 1:

The following table shows the various variables involved in this experiment. These are: Independent Variable, Dependent Variable and Controlled Variables

Variables

Description/Reasoning

Independent variable

Sodium iodine (NaI) mass (g)

Used NaI in 10 separate increments of 0.15g starting at 0.75g

Dependent variable

Lead iodine (PbI2) mass (g)

The mass of PbI2 depended on the change of NaI and each reaction was measured.

Controlled variables

Lead (II) nitrate {Pb(NO3)2} mass (g)

1.66g of Pb(NO3)2 was used in each experiment

Water (H2O)

30ml used in each experiment

Balancing equipment (2-place)

Each experiment used the same balancer

Precipitation waiting time

All 3 - 5 minutes

Drying time

All kept overnight

Temperature

all in a 100?C (Fahrenheit)/35?C (degrees) oven overnight

Conditions of the experiment

Experimental process on the same day as each other

6. Safety Measures

Table 2:

This table shows the shows the safety measures considered prior and during the experiment.

Hazards

Risk

Safety Precaution

Chemical

Eye damage

- Safety Glasses

Skin Damage

- Lab coat
- gloves
- long pants
- Hard covered shoes

Inhalation

- Do not look directly over reactions
- do not smell products (wafting technique)
- be careful with observations

Poisoning/Consumption

- Handle with extreme caution,
- dispose immediately of waste once used, wear gloves,
- do not consume

Equipment/Glass ware

Glass Breakage

- Handle glassware with care,
- place away from edge when not in use

Injury to skin/cuts

- handle any broken glass with care
- handle all things with care

7. Method

1. The Equipment and chemicals were collected and all safety measures adhered to.
2. The filter paper was folded into quarters and then it was weighed. The weight of the filter paper was then written down on the board in a table with the corresponding experiment number.
3. Both the Lead (II) nitrate and the NaI was measured out on weigh boats to the closest possible reading.
4. The mass of the Lead (II) nitrate was written down on both sides of the filter paper at the open end of the fold.
5. 30ml of deionised water was added to each of the 100ml beakers.
6. Each measured reactant was transferred into separate beakers. Then the weigh boats were rinsed with deionised water and added to ensure no transferring error occurred.
7. Each solution was then stirred with the stirring rod.
8. The Lead (II) nitrate solution was then carefully added to the Sodium iodine mixture. Then the beaker was rinsed out with the deionised water 3 times to ensure no transferring error occurred.
9. The new Lead (II) nitrate and Sodium iodine mixture was stirred and then left for 3 - 5 minutes.

10. The filter paper was then placed into a filter funnel which was sitting in a 100ml conical flask. Then deionised water was filtered through to ensure the paper stayed in place.
11. The precipitated solution was then transferred through the filter paper creating filtration and yellow residue.
12. To ensure a complete transfer the beaker was rinsed multiple times with deionised water as well as ethanol.
13. After the filtration process finalised the filtration paper was carefully removed from the funnel and placed into a beaker by the instructor.
14. The instructor then placed all of the beakers into the oven which was 100?C (Fahrenheit)/35?C (degrees) and it was left overnight.
15. The next morning the instructor then removed the paper and allowed to cool then began reweighing the filter paper and precipitate. The difference of the filter paper was then found through deducting the original mass from the filter paper with the residue's mass.

Results

Table

Table 3:

This table shows the moles and grams of Lead (II) nitrate and Sodium iodine used in the experiment. It also shows the theoretical, actual and percentage yield of lead iodine produced.

Sample No.

Mass Pb(NO3)2

Mass NaI (g)

Moles Pb(NO3)2

Moles NaI

Actual Yield PbI2 (g)

Actual Yield PbI2 (moles)

Theoretical Yield PbI2 (Moles)

Theoretical Yield PbI2 (g)

Percentage by mass (%)

1

1.66

0.75 g

5.0 x10-3

5.0 x10-3

1.36 g

2.95 x10-3

2.5 x10-3

1.15 g

118.26%

2

1.66

0.90 g

5.0 x10-3

6.0 x10-3

1.38 g

3.00 x10-3

3.0 x10-3

1.38 g

100%

3

1.66

1.05 g

5.0 x10-3

7.0 x10-3

1.52 g

3.30 x10-3

3.5 x10-3

1.61 g

94.40%

4

1.66

1.20 g

5.0 x10-3

8.0 x10-3

1.83 g

3.97 x10-3

4.0 x10-3

1.84 g

99.50%

5

1.66

1.35 g

5.0 x10-3

9.0 x10-3

1.93 g

4.19 x10-3

4.5 x10-3

2.08 g

92.79%

6

1.66

1.50 g

5.0 x10-3

1.0 x10-2

2.21 g

4.70 x10-3

5.0 x10-3

2.31 g

95.67%

7

1.66

1.65 g

5.0 x10-3

2.0 x10-2

2.32 g

5.03 x10-3

5.0 x10-3

2.31 g

100.43%

8

1.66

1.80 g

5.0 x10-3

3.0 x10-2

2.36 g

5.12 x10-3

5.0 x10-3

2.31 g

102.16%

9

1.66

1.95 g

5.0 x10-3

4.0 x10-2

2.36 g

5.12 x10-3

5.0 x10-3

2.31 g

102.16%

10

1.66

2.10 g

5.0 x10-3

5.0 x10-2

2.42 g

5.25 x10-3

5.0 x10-3

2.31 g

104.76%

8. Refence List

1. Washington University in St. Louis, 2005. http://www.chemistry.wustl.edu/~coursedev/Online%20tutorials/Stoichiometry.htm Dr.

Kristy M. Bailey no date Professor of Chemistry
2. Oklahoma City Community College http://www.occc.edu/kmbailey/Chem1115Tutorials/Stoichiometry_Map.htm
3. Khan Academy 2019 https://www.khanacademy.org/science/chemistry/chemical-reactions-stoichiome/limiting-reagent-stoichiometry/a/limiting-reagents-and-percent-yield
4. Anne Marie Helmenstine, Ph.D. updated July 14, 2019, https://www.thoughtco.com/theoretical-yield-definition-602125