If 24.2 G Of Zinc Is Combined With Hydrochloric Acid (HCl) Determine The Concentration Of The Zinc Chloride

If 24.2 G Of Zinc Is Combined With Hydrochloric Acid (HCl) Determine The Concentration Of The Zinc Chloride

Understanding the chemical reaction between zinc and hydrochloric acid is fundamental in chemistry, especially in fields involving metallurgy, materials science, and industrial chemistry. This article provides a comprehensive explanation of how to determine the concentration of zinc chloride formed when zinc reacts with hydrochloric acid, based on a given mass of zinc. We'll walk through the chemical principles, calculations, and real-world applications to ensure a thorough understanding.

Introduction to the Reaction Between Zinc and Hydrochloric Acid

The reaction between zinc (Zn) and hydrochloric acid (HCl) is a classic example of a single displacement reaction, where a more reactive metal displaces a less reactive hydrogen ion from an acid. The general chemical equation for this reaction is:

Balanced Chemical Equation

$Zn\ (s) + 2\ HCl\ (aq) \rightarrow ZnCl_2\ (aq) + H_2\ (g)$

This equation indicates that one mole of zinc reacts with two moles of hydrochloric acid to produce one mole of zinc chloride and one mole of hydrogen gas.

Understanding the Key Concepts and Calculations

To determine the concentration of zinc chloride in solution after the reaction, we need to follow a series of steps grounded in stoichiometry, the branch of chemistry that relates the quantities of reactants and products in a chemical reaction.

1. Calculating Moles of Zinc Used

Given:

- Mass of zinc (Zn) = 24.2 grams

Molecular weight of zinc (Zn):

- Atomic mass of Zn 65.38 g/mol

Calculating moles:

$$\text{Moles of Zn} = \text{Mass} / \text{Molar mass} = 24.2\ \text{g} / 65.38\ \text{g/mol} \approx 0.3702\ \text{mol}$$

2. Determining Moles of Zinc Chloride Produced

From the balanced equation, the molar ratio of zinc to zinc chloride is 1:1. Therefore:

$$\text{Moles of } ZnCl_2 \text{ produced} = \text{Moles of Zn reacted} = 0.3702\ \text{mol}$$

3. Calculating the Mass of Zinc Chloride Formed

Molecular weight of zinc chloride ($ZnCl_2$):

- Zn: 65.38 g/mol
- Cl: 35.45 g/mol
- Total: 65.38 + 2 35.45 = 65.38 + 70.90 = 136.28 g/mol

Mass of $ZnCl_2$ formed:

$$\text{Mass} = \text{Moles} \times \text{Molar mass} = 0.3702 \text{ mol} \times 136.28 \text{ g/mol} \approx 50.5 \text{ g}$$

Calculating the Concentration of Zinc Chloride

The concentration of a solution (usually expressed in molarity, M) is defined as the number of moles of solute per liter of solution:

$$\text{Molarity (M)} = \text{Moles of solute} / \text{Volume of solution in liters}$$

To determine the concentration of zinc chloride, the volume of the solution in which it is dissolved must be known. Since the problem statement does not specify the volume of hydrochloric acid used, we will explore scenarios based on different volumes, illustrating how concentration varies with solution volume.

1. Concentration When the Zinc Is Dissolved in a Known Volume of HCl

Suppose the zinc reacts with a known volume of hydrochloric acid, say, 1 liter (L):

1. Number of moles of zinc chloride formed: 0.3702 mol

2. Volume of solution: 1 L

Thus, the concentration:

```
Concentration = 0.3702 mol / 1 L = 0.3702 M
```

If the volume differs, simply divide the moles by the volume in liters.

2. Concentration in Different Volumes

Volume of solution (L)	Concentration (M)
0.5	0.3702 / 0.5 = 0.7404 M
1	0.3702 M
2	0.3702 / 2 = 0.1851 M
5	0.3702 / 5 = 0.0740 M

This table illustrates how the concentration decreases as the volume of solution increases, assuming all zinc is dissolved and reacts completely.

Real-World Applications of Zinc Chloride Production

Understanding the concentration of zinc chloride has practical implications in various industries:

1. Industrial Manufacturing

Zinc chloride is used in galvanizing processes, where zinc coatings protect steel from corrosion. Precise concentration control ensures optimal coating quality.

2. Chemical Synthesis

Zinc chloride serves as a catalyst or reagent in organic synthesis, where stoichiometric calculations are crucial for efficiency and safety.

3. Water Treatment

Zinc compounds, including zinc chloride, are sometimes used in water purification processes, making understanding their concentrations vital for environmental safety.

Factors Affecting the Calculation of Zinc Chloride Concentration

While the calculations above assume complete reaction and no side reactions, real-world scenarios may involve variables such as:

- Incomplete reaction: Not all zinc may react, especially if the acid is limiting.
- Solution volume: Precise measurement is essential for accurate concentration determination.
- Purity of reactants: Impurities can affect the molar ratios and yield.
- Temperature and pressure: These can influence reaction rates and solubility.

Proper laboratory techniques and precise measurements are essential to minimize errors in calculations.

Summary of Step-by-Step Process

To summarize, here is a concise overview of how to determine the concentration of zinc chloride:

1. Calculate moles of zinc from the given mass.
2. Use the molar ratio from the balanced reaction to find moles of zinc chloride produced.
3. Determine the molar mass of zinc chloride.
4. Calculate the mass of zinc chloride formed.
5. Divide the moles of zinc chloride by the volume of solution to find molarity.

Conclusion

Determining the concentration of zinc chloride formed when zinc reacts with hydrochloric acid is a straightforward process grounded in stoichiometry. Given a specific mass of zinc, calculating the moles, then the mass, and finally the concentration depends on knowing the volume of solution involved. Accurate measurements and understanding of the reaction principles are vital for applications in industrial processes, laboratory experiments, and environmental management. By mastering these calculations, chemists and engineers can optimize processes, ensure safety, and produce desired

chemical products efficiently.

References

- Zumdahl, S. S., & Zumdahl, S. A. (2014). Chemistry: An Atoms First Approach. Cengage Learning.
- Petrucci, R. H., Herring, F. G., Madura, J. D., & Bissonnette, C. (2017). General Chemistry: Principles & Modern Applications. Pearson.
- Standard Laboratory Procedures and Safety Data Sheets (SDS) for Zinc and Hydrochloric Acid.

This detailed guide provides the necessary steps and considerations to accurately determine the concentration of zinc chloride produced in a reaction with hydrochloric acid, emphasizing the importance of stoichiometric calculations and precise measurements in chemistry.

Frequently Asked Questions

What is the balanced chemical equation for the reaction between zinc and hydrochloric acid?

The balanced chemical equation is: Zn + 2HCl □ ZnCl□ + H□.

How do you calculate the number of moles of zinc in 24.2 grams?

Number of moles = mass / molar mass. For zinc, molar mass ≈ 65.38 g/mol, so moles = 24.2 / 65.38 ≈ 0.370 mol.

What is the molar mass of zinc chloride ($ZnCl_2$)?

The molar mass of $ZnCl_2$ is approximately 136.3 g/mol (Zn ≈ 65.38, Cl ≈ 35.45 × 2).

How many moles of zinc chloride are produced from 0.370 mol of zinc?

Since 1 mol of Zn produces 1 mol of $ZnCl_2$, 0.370 mol of zinc produces 0.370 mol of zinc chloride.

How do you determine the concentration of zinc chloride in the solution?

Concentration (M) = moles of solute / volume of solution in liters. You need the total volume of the solution to calculate this.

If the volume of the solution is 1 liter, what is the concentration of zinc chloride?

Concentration = 0.370 mol / 1 L = 0.370 M.

What assumptions are made when calculating the concentration of zinc chloride?

Assumptions include complete reaction of zinc with HCl, no side reactions, and that the final solution volume is known or remains unchanged after reaction.

How does the amount of hydrochloric acid used affect the calculation of concentration?

The amount of HCl determines the extent of the reaction. For complete reaction, HCl should be in excess; otherwise, limiting reagent considerations are necessary.

Can the concentration of zinc chloride be determined without knowing the total solution volume?

No, the concentration requires knowing the total volume of the solution in liters to calculate molarity accurately.

What are common methods to measure the concentration of zinc chloride in the lab?

Methods include titration with a standard solution, spectrophotometry, or using conductivity measurements, depending on available equipment and required accuracy.

Additional Resources

If 24.2 G Of Zinc Is Combined With Hydrochloric Acid (HCl) Determine The Concentration Of The Zinc Chloride

The reaction between zinc and hydrochloric acid is a classic example in chemistry that illustrates fundamental principles of stoichiometry, chemical reactions, and solution chemistry. When zinc metal interacts with hydrochloric acid, it produces zinc chloride and hydrogen gas, a reaction that is both practically important in industrial processes and educationally significant for understanding chemical equivalence and concentration calculations. This article delves into the detailed steps to determine the concentration of zinc chloride formed when 24.2 grams of zinc react with hydrochloric acid, emphasizing the theoretical background, reaction mechanisms, and calculation methodologies.

Understanding the Fundamentals of the Zinc-HCl Reaction

The Chemical Equation

The primary reaction between zinc and hydrochloric acid can be summarized by the balanced chemical equation:

$$ \text{Zn (s)} + 2 \text{HCl (aq)} \rightarrow \text{ZnCl}_2 \text{(aq)} + \text{H}_2 \text{(g)} $$

This equation indicates that one mole of zinc reacts with two moles of hydrochloric acid to produce one mole of zinc chloride and hydrogen gas. Recognizing the stoichiometry is crucial for calculating the amount of zinc chloride generated.

Reaction Conditions and Stoichiometry

- Reactants: Solid zinc (Zn) and aqueous hydrochloric acid (HCl).
- Products: Zinc chloride ($ZnCl_2$) dissolved in solution and hydrogen gas evolved.
- Stoichiometric Ratios: 1 mol Zn : 2 mol HCl : 1 mol $ZnCl_2$.

Understanding these ratios allows chemists to calculate the amount of product formed based on the initial quantities of reactants.

Calculating Moles of Zinc Reacted

Molecular Weight of Zinc

The atomic weight of zinc (Zn) is approximately 65.38 g/mol. This value is essential for converting mass to moles:

$$ \text{Moles of Zn} = \frac{\text{Mass of Zn}}{\text{Molecular weight of Zn}} $$

Applying the given data:

$$ \text{Moles of Zn} = \frac{24.2\, \text{g}}{65.38\, \text{g/mol}} \approx 0.370\, \text{mol} $$

This calculation confirms that approximately 0.370 moles of zinc are involved in the reaction.

Determining the Amount of Zinc Chloride Formed

Stoichiometric Relationship

From the balanced chemical equation, the mole ratio of zinc to zinc chloride is 1:1. Therefore:

$$ \text{Moles of ZnCl}_2 \text{ formed} = \text{Moles of Zn reacted} $$

Thus,

$$ \text{Moles of ZnCl}_2 = 0.370\, \text{mol} $$

Mass of Zinc Chloride Produced

The molecular weight of zinc chloride ($ZnCl_2$) can be calculated as:

$$\text{Molecular weight of } ZnCl_2 = 65.38\, (\text{Zn}) + 2 \times 35.45\, (\text{Cl}) = 65.38 + 70.90 = 136.28\, \text{g/mol}$$

Using this, the mass of zinc chloride produced is:

$$\text{Mass of } ZnCl_2 = \text{moles} \times \text{molecular weight}$$

$$= 0.370\, \text{mol} \times 136.28\, \text{g/mol} \approx 50.5\, \text{g}$$

Hence, from 24.2 grams of zinc, approximately 50.5 grams of zinc chloride are formed, assuming complete reaction.

Determining the Concentration of Zinc Chloride in Solution

Assumption of Complete Reaction and Dissolution

For the purpose of concentration calculation, it is assumed that all zinc chloride produced dissolves uniformly in the solution, and the reaction proceeds to completion with no side reactions.

Volume of the Solution

To determine concentration, the total volume of the solution in which zinc chloride is dissolved is necessary. Since the problem statement does not specify the volume of hydrochloric acid used, the typical approach involves assuming a certain volume or considering the volume of the acid solution

used in the reaction.

Common scenarios:

- If the volume of HCl solution used is known, concentration can be directly calculated.
- If not specified, a standard volume (for example, 1 liter) can be assumed to illustrate the calculation.

For illustrative purposes, assume that the reaction occurs in 1 liter (1000 mL) of solution.

Calculating Concentration

Concentration is expressed in molarity (M), which is moles of solute per liter of solution:

$$ \text{Concentration (M)} = \frac{\text{Moles of solute}}{\text{Volume of solution in liters}} $$

Given that:

$$ \text{Moles of ZnCl}_2 = 0.370\, \text{mol} $$
$$ \text{Volume} = 1\, \text{L} $$

The molarity of zinc chloride is:

$$ \boxed{
\text{Concentration} = \frac{0.370\, \text{mol}}{1\, \text{L}} = 0.370\, \text{M}
} $$

This indicates a concentration of approximately 0.370 molar zinc chloride in the solution.

Factors Influencing the Accuracy of the Calculation

Reaction Completeness and Purity

- The calculation assumes complete reaction with no zinc left unreacted. In practical scenarios, reaction efficiency might be less than 100%, affecting concentration.
- Purity of zinc and hydrochloric acid can influence the actual amount of zinc chloride produced.

Volume Measurement and Dilution

- Precise measurement of the final solution volume is critical. Any dilution or evaporation alters the concentration.
- If hydrochloric acid is used in excess, the reaction will go to completion, but the final volume might change due to additional acid or water present.

Side Reactions and Experimental Conditions

- Presence of impurities or side reactions can reduce yield.
- Temperature and pressure conditions can influence solubility and reaction extent.

Industrial and Educational Implications

Industrial Relevance

Understanding the stoichiometry and concentration calculations of zinc chloride is vital in various industrial applications, including:

- Electroplating processes, where zinc chloride acts as a source of zinc ions.
- Chemical manufacturing, where precise concentrations are required for product quality.
- Waste treatment, to neutralize acids and recover zinc.

Educational Significance

This problem exemplifies core chemistry concepts:
- Mole concept and molar relationships.
- Balancing chemical equations.
- Quantitative analysis and concentration calculation.
- Practical applications of theoretical chemistry.

Conclusion

The reaction between zinc and hydrochloric acid demonstrates the elegance of stoichiometry and the importance of precise measurements in chemical calculations. From a given mass of zinc, it is possible to determine the amount of zinc chloride produced and its concentration in solution, provided that the reaction proceeds to completion and the solution volume is known. In the example explored, 24.2 grams of zinc reacting in an assumed 1-liter solution yields a zinc chloride concentration of approximately 0.370 M. Such calculations are fundamental in chemical analysis and process engineering, highlighting the interplay between theoretical principles and practical applications.

Final note: Precise experimental conditions and measurements are vital for accurate determination of concentrations in real-world scenarios. Nonetheless, the methodology outlined provides a solid foundation for understanding and performing similar calculations in laboratory and industrial settings.

If 24 2 G Of Zinc Is Combined With Hydrochloric Acid Hcl Determine The Concentration Of The Zinc Chloride

If 24 2 G Of Zinc Is Combined With Hydrochloric Acid Hcl Determine The Concentration Of The Zinc Chloride

Related Articles

- Find The Value Of Y0 For Which The Solution Of The Initial Value Problem Y Y = 1 3 Sin T, Y(0) = Y0 Remains
- Stacy BelizairePlay 6Samir And Raul Play On The Same Basketball Team. During The3last Game, Samir Scored5of
- Outline How 14C In Carbon Dioxide Gas Becomes Incorporated Into The Sucrose Molecules That Are Translocated

Back to Home