In The Reaction, Zn 2 Hcl Zncl2 H2, 25.0 Grams Of Zn Are Reacted With 17.5 G Of Hcl. How Many Grams Of

In The Reaction, Zn 2 Hcl Zncl2 H2, 25.0 Grams Of Zn Are Reacted With 17.5 G Of Hcl. How Many Grams Of the products are formed? This question involves understanding the fundamental principles of chemical reactions, stoichiometry, and mole calculations. To accurately determine the amount of products generated or reactants consumed, it's essential to analyze the reaction step-by-step, considering the molar ratios, molar masses, and the limiting reagent. In this comprehensive guide, we will explore the reaction details, perform necessary calculations, and elucidate the process involved in solving such chemical problems.

Understanding the Chemical Reaction

The Reaction Equation

The reaction in question involves zinc (Zn) reacting with hydrochloric acid (HCl), producing zinc chloride ($ZnCl_2$) and hydrogen gas (H_2). The balanced chemical equation for this reaction is:

$$Zn + 2\ HCl \rightarrow ZnCl_2 + H_2$$

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.

Key Components and Their Roles

- Zinc (Zn): The metallic reactant, used in a specific mass.
- Hydrochloric acid (HCl): The acid reactant, also provided in a specific mass.
- Zinc chloride ($ZnCl_2$): The primary product resulting from the reaction.
- Hydrogen gas (H_2): A gaseous byproduct.

Calculating Moles of Reactants

Step 1: Find the molar mass of each reactant

Substance	Molar Mass (g/mol)	Calculation
Zinc (Zn)	65.38 g/mol	-
Hydrochloric acid (HCl)	36.46 g/mol	-

Step 2: Determine moles of each reactant used

- Moles of Zn:

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n(Zn) = mass / molar mass = 25.0 g / 65.38 g/mol ≈ 0.3825 mol
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- Moles of HCl:

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n(HCl) = 17.5 g / 36.46 g/mol ≈ 0.4795 mol
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Identifying the Limiting Reagent

Step 3: Use the molar ratio from the balanced equation

- The reaction requires 2 moles of HCl per 1 mole of Zn.

- Calculate the amount of HCl needed to react completely with 0.3825 mol of Zn:

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HCl needed = 2 × 0.3825 mol = 0.765 mol
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- Compare with available HCl:

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Available HCl = 0.4795 mol
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Since 0.4795 mol < 0.765 mol, HCl is the limiting reagent.

Conclusion: The reaction is limited by HCl; zinc is in excess.

Calculating the Theoretical Yield of Products

Step 4: Determine the amount of $ZnCl_2$ formed

- The molar ratio of Zn to $ZnCl_2$ is 1:1.

- The moles of $ZnCl_2$ produced are equal to the moles of limiting reagent HCl divided by 2 (since 2 HCl produce 1 $ZnCl_2$).

But since HCl is limiting and in a molar amount of 0.4795 mol:

- Moles of $ZnCl_2$ formed:

$$n(ZnCl_2) = n(HCl) / 2 = 0.4795 \text{ mol} / 2 \approx 0.23975 \text{ mol}$$

- Mass of $ZnCl_2$ produced:

$$\text{Mass} = n \times \text{molar mass}$$

- Molar mass of $ZnCl_2$:

$$\text{Zn: } 65.38 \text{ g/mol}$$
$$\text{Cl: } 35.45 \text{ g/mol}$$
$$\text{Molar mass of } ZnCl_2 = 65.38 + 2 \times 35.45 = 136.28 \text{ g/mol}$$

- Mass of $ZnCl_2$:

$$\text{Mass} = 0.23975 \text{ mol} \times 136.28 \text{ g/mol} \approx 32.66 \text{ g}$$

Step 5: Determine the amount of Hydrogen Gas (H_2) produced

- The molar ratio from the balanced equation indicates 1 mol of Zn produces 1 mol of H_2.

- The amount of Zn reacted is 0.3825 mol, so:

$$n(H_2) = 0.3825 \text{ mol}$$

- Mass of H_2 gas:

```
Molar mass of H₂ = 2.02 g/mol
Mass of H₂ = 0.3825 mol × 2.02 g/mol ≈ 0.772 g
```

Summary of Results

Product	Moles	Mass (g)
$ZnCl_2$	0.23975 mol	32.66 g
H_2	0.3825 mol	0.772 g

Note: Since HCl is limiting, only 17.5 g of HCl can react completely with approximately 25 g of Zn, producing 32.66 grams of $ZnCl_2$ and 0.772 grams of H_2.

Implications and Practical Applications

Industrial Significance

This reaction is fundamental in the production of zinc salts and hydrogen gas, both of which have significant industrial applications. Zinc chloride is used in textile processing, wood preservation, and as a catalyst in various chemical reactions. Hydrogen gas, on the other hand, is a clean fuel source and an essential component in chemical manufacturing, including ammonia synthesis.

Reactivity and Safety Considerations

- Reactivity: Zinc reacts vigorously with acids, releasing hydrogen gas, which is flammable. Proper safety protocols must be followed during such reactions.
- Handling Acid: Hydrochloric acid is corrosive; appropriate protective equipment is necessary.
- Gas Collection: Hydrogen gas should be collected and stored safely to prevent fire hazards.

Additional Factors in Real-World Scenarios

- Purity of Reactants: The calculations assume pure zinc and HCl; impurities can affect reaction efficiency.

- Reaction Conditions: Temperature, pressure, and concentration influence reaction rates and yields.
- Incomplete Reactions: In practical settings, reactions might not go to completion, affecting the actual yields.

Conclusion

In the reaction between zinc and hydrochloric acid, the limiting reagent determines the maximum amount of products formed. Given 25.0 grams of zinc and 17.5 grams of HCl, hydrochloric acid limits the reaction, producing approximately 32.66 grams of zinc chloride and 0.772 grams of hydrogen gas. Understanding these calculations helps chemists optimize reactions, predict yields, and design efficient industrial processes. The principles demonstrated here—stoichiometry, molar conversions, and limiting reagent analysis—are fundamental tools in the chemist's toolkit for solving a wide array of chemical problems.

Remember: Always double-check your calculations, consider reaction conditions, and understand the theoretical versus actual yields when applying these principles in real-world applications.

Frequently Asked Questions

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

The balanced chemical equation is $Zn + 2\ HCl \rightarrow ZnCl_2 + H_2$.

How do you determine the limiting reactant in the reaction between 25.0 g of Zn and 17.5 g of HCl?

Calculate moles of each reactant: for Zn, moles = 25.0 g / 65.38 g/mol; for HCl, moles = 17.5 g / 36.46 g/mol. The reactant with fewer moles relative to the stoichiometric ratio is limiting.

What is the theoretical yield of hydrogen gas (H_2) in grams when 25.0 g of Zn reacts completely?

First, find moles of Zn: 25.0 g / 65.38 g/mol ≈ 0.383 mol. Since 1 mol Zn produces 1 mol H_2, the moles of H_2 produced are 0.383 mol. Convert to grams: 0.383 mol × 2.02 g/mol ≈ 0.775 g of H_2.

How much zinc chloride ($ZnCl_2$) is formed when 25.0 g of Zn

reacts completely?

Moles of Zn = 0.383 mol. Since 1 mol Zn produces 1 mol $ZnCl_2$, moles of $ZnCl_2$ = 0.383 mol. Mass of $ZnCl_2$ = 0.383 mol × 136.29 g/mol ≈ 52.3 g.

If only 17.5 g of HCl is available, what is the actual amount of hydrogen gas produced?

Calculate moles of HCl: 17.5 g / 36.46 g/mol ≈ 0.48 mol. Since the reaction requires 2 mol HCl per mol Zn, the limiting reactant is HCl. Moles of Zn reacting = 0.48 mol / 2 = 0.24 mol. Moles of H_2 produced = 0.24 mol. Convert to grams: 0.24 mol × 2.02 g/mol ≈ 0.485 g.

What is the percent yield of hydrogen gas in this reaction if the actual yield is 0.485 g?

Percent yield = (actual yield / theoretical yield) × 100%. Theoretical yield (from 25.0 g Zn) is approximately 0.775 g. Therefore, percent yield = (0.485 / 0.775) × 100% ≈ 62.6%.

Additional Resources

Reaction of Zinc with Hydrochloric Acid: An In-Depth Analysis

When exploring chemical reactions, especially those involving metals and acids, understanding the stoichiometry and the underlying principles is crucial. Today, we delve into the reaction between zinc (Zn) and hydrochloric acid (HCl), focusing on the specific quantities involved—25.0 grams of zinc reacting with 17.5 grams of hydrochloric acid—and analyzing the resulting products and theoretical yields. This detailed examination provides insights not only into the reaction mechanism but also into how quantitative data guides us in predicting and verifying chemical outcomes.

Understanding the Reaction: Zinc and Hydrochloric Acid

At its core, the reaction between zinc and hydrochloric acid is a classic example of a single replacement reaction, where a metal reacts with an acid to produce a salt and hydrogen gas. The general chemical equation for this reaction is:

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

Key Points:

- Zinc (Zn): a metallic element, often used in galvanization, batteries, and as a reactant in various chemical processes.
- Hydrochloric acid (HCl): a strong acid, commonly used in laboratories and industries.

- Zinc chloride ($ZnCl_2$): a soluble salt, used in various applications including de-icing, textile processing, and as a catalyst.
- Hydrogen gas (H_2): a clean fuel, also produced in many industrial processes.

Quantitative Analysis: Starting Materials and Moles

To understand how much product can be formed, we need to convert the given mass of reactants into moles. This allows us to analyze the reaction on a molar basis, which is essential for stoichiometric calculations.

Calculating Moles of Zinc (Zn)

- Given Data: 25.0 grams of Zn
- Atomic mass of Zn: approximately 65.38 g/mol

$$
\text{Moles of Zn} = \frac{\text{Mass of Zn}}{\text{Atomic mass of Zn}} = \frac{25.0\, \text{g}}{65.38\, \text{g/mol}} \approx 0.382\, \text{mol}
$$

Calculating Moles of Hydrochloric Acid (HCl)

- Given Data: 17.5 grams of HCl
- Molar mass of HCl: approximately 36.46 g/mol

$$
\text{Moles of HCl} = \frac{\text{Mass of HCl}}{\text{Molar mass of HCl}} = \frac{17.5\, \text{g}}{36.46\, \text{g/mol}} \approx 0.48\, \text{mol}
$$

Determining the Limiting Reactant

The balanced chemical equation indicates that:

$$ 1\, \text{mol} \text{ Zn} : 2\, \text{mol} \text{ HCl} $$

This molar ratio is critical in identifying the limiting reactant—the reactant that determines the maximum amount of product formed.

Comparison:

- For 0.382 mol of Zn, the required HCl is:

$$
0.382\, \text{mol Zn} \times 2\, \text{mol HCl/mol Zn} = 0.764\, \text{mol HCl}
$$

- Actual moles of HCl present: 0.48 mol

Since only 0.48 mol of HCl is available, which is less than the 0.764 mol needed to react with all zinc, HCl is the limiting reactant in this scenario.

Calculating Theoretical Yields

Knowing the limiting reactant allows us to predict the maximum amount of products formed, specifically zinc chloride ($ZnCl_2$) and hydrogen gas (H_2).

Mass of Zinc Chloride ($ZnCl_2$) Formed

- Reaction stoichiometry: 1 mol Zn produces 1 mol $ZnCl_2$
- Moles of $ZnCl_2$ formed: equal to moles of Zn reacting, which is limited by HCl

Since HCl is limiting, it determines the amount of zinc chloride formed:

$$
\text{Moles of ZnCl}_2 = \text{Moles of HCl used} \div 2
$$

But because 2 mol HCl reacts with 1 mol Zn, and only 0.48 mol HCl is available:

$$
\text{Moles of Zn reacting} = \frac{0.48\, \text{mol HCl}}{2} = 0.24\, \text{mol}
$$

- Mass of $ZnCl_2$ produced:

- Molar mass of $ZnCl_2$:

$$
65.38\, \text{g/mol} + 2 \times 35.45\, \text{g/mol} = 136.28\, \text{g/mol}
$$

$$
\text{Mass of ZnCl}_2 = 0.24\, \text{mol} \times 136.28\, \text{g/mol} \approx 32.7\, \text{g}
$$

\]

Thus, the maximum theoretical yield of zinc chloride is approximately 32.7 grams.

Mass of Hydrogen Gas (H_2) Produced

- For every 2 mol HCl reacted, 1 mol H_2 is produced.
- Moles of H_2:

$$
\frac{0.48\, \text{mol HCl}}{2} = 0.24\, \text{mol}
$$

- Mass of H_2:

- Molar mass of H_2: approximately 2.016 g/mol

$$
0.24\, \text{mol} \times 2.016\, \text{g/mol} \approx 0.484\, \text{g}
$$

Hence, approximately 0.48 grams of hydrogen gas can be produced under ideal conditions.

Practical Considerations and Real-World Implications

While calculations provide a theoretical maximum, actual yields often vary due to factors like incomplete reactions, side reactions, and experimental conditions. Nevertheless, understanding these calculations guides chemists and engineers in designing processes, estimating outputs, and optimizing reaction conditions.

Key Takeaways:

- The limiting reactant concept ensures accurate prediction of product yields.
- Precise molar calculations are essential for quantitative chemistry.
- Safety considerations—especially with hydrogen gas—are critical in practical scenarios.

Summary of Findings

Quantity	Calculated Value	Explanation
Moles of Zn	approximately 0.382 mol	Based on 25.0 g of Zn

Moles of HCl	approximately 0.48 mol	Based on 17.5 g of HCl
Limiting Reactant	HCl	Less than required for complete reaction
Max $ZnCl_2$ produced	approximately 32.7 g	Based on limiting HCl
Hydrogen gas produced	approximately 0.48 g	Based on limiting HCl

This comprehensive analysis underscores the importance of stoichiometry in predicting reaction outcomes. Whether in laboratory research, industrial manufacturing, or educational demonstrations, understanding these principles ensures accurate, efficient, and safe chemical processes.

Final Thoughts: Applying This Knowledge

The reaction between zinc and hydrochloric acid exemplifies fundamental chemical principles that are applicable across various fields—from materials science to environmental engineering. Mastery of molar conversions, limiting reactant determination, and yield calculations empowers chemists and engineers to innovate, optimize, and troubleshoot effectively.

In conclusion, this detailed exploration not only clarifies the specific reaction scenario but also reinforces the universal importance of quantitative analysis in chemistry. By understanding how to navigate these calculations, professionals can confidently predict product quantities, assess reaction efficiency, and design safer, more effective chemical processes.

Disclaimer: Always conduct chemical reactions with appropriate safety measures and in suitable laboratory environments.

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