When A Student Adds 30.0mL Of 1.00M HCl To 0.56g Of Powdered Fe, A Reaction Occurs According To The Equation

When A Student Adds 30.0mL Of 1.00M HCl To 0.56g Of Powdered Fe, A Reaction Occurs According To The Equation is a classic demonstration of acid-metal reactions in chemistry. This process not only showcases fundamental principles of stoichiometry and chemical reactivity but also provides insights into how metals interact with acids to produce hydrogen gas and metal salts. Understanding this reaction involves examining the chemical equation, calculating the amounts of reactants involved, and analyzing the reaction's outcome. This article explores these aspects in detail to provide a comprehensive understanding of the reaction between hydrochloric acid (HCl) and powdered iron (Fe).

Understanding the Reaction Between HCl and Iron

The Chemical Equation

The reaction between hydrochloric acid and iron can be summarized by the following balanced chemical equation:

- $Fe (s) + 2HCl (aq) \rightarrow FeCl_2 (aq) + H_2 (g)$

This indicates that one atom of iron reacts with two molecules of hydrochloric acid to produce iron(II) chloride ($FeCl_2$) and hydrogen gas (H_2). The reaction is a typical single displacement reaction where a metal displaces hydrogen from an acid.

Significance of the Reaction

This reaction is significant for several reasons:

- Demonstrates metal-acid reactivity and redox processes
- Produces hydrogen gas, a clean fuel source
- Forms soluble metal salts, useful in various industrial applications

Calculating the Moles of Reactants

Determining Moles of HCl

Given:

- Volume of HCl solution = 30.0 mL = 0.030 L
- Concentration of HCl = 1.00 M

The number of moles of HCl can be calculated using molarity:

Moles of HCl = concentration × volume = 1.00 mol/L × 0.030 L = 0.030 mol

Calculating Moles of Iron (Fe)

Given:

- Mass of powdered iron = 0.56 g
- Molar mass of Fe ≈ 55.85 g/mol

Number of moles of Fe:

Moles of Fe = mass / molar mass = 0.56 g / 55.85 g/mol ≈ 0.01004 mol

Analyzing the Reaction and Limiting Reactant

Stoichiometric Ratios

From the balanced equation:

- 1 mol of Fe reacts with 2 mol of HCl

Calculating the required amount of HCl for all the Fe:

Required HCl = 0.01004 mol Fe × 2 mol HCl / 1 mol Fe = 0.02008 mol HCl

Since the available HCl is 0.030 mol, which exceeds the required 0.02008 mol, iron is the limiting reactant. The reaction will proceed until all the iron is consumed.

Extent of the Reaction

The amount of hydrogen gas produced can be determined from the limiting reactant:

Hydrogen gas produced = moles of Fe reacted = 0.01004 mol

This amount of hydrogen gas corresponds to the reaction's maximum extent under the given conditions.

Predicting the Products and Observations

Formation of Iron(II) Chloride

The soluble product is iron(II) chloride ($FeCl_2$), which dissolves in water, creating an aqueous solution that may appear greenish or pale yellow, depending on concentration.

Hydrogen Gas Evolution

The reaction produces hydrogen gas, which can be observed as bubbling or effervescence during the process. Collecting this gas can demonstrate the reaction's occurrence and quantify the amount of hydrogen generated.

Practical Implications

This reaction is often used in laboratory demonstrations to:

- Showcase acid-metal reactions
- Generate hydrogen gas for further experiments
- Study stoichiometry and limiting reactants

Safety Considerations and Best Practices

Handling Hydrochloric Acid

HCl is corrosive and can cause burns. Use appropriate personal protective equipment (PPE), including gloves, goggles, and lab coats.

Managing Hydrogen Gas

Hydrogen is flammable and explosive in high concentrations. Conduct reactions in well-ventilated areas, away from open flames, and use appropriate gas collection methods.

Dealing with Iron Powder

Iron powder can be a respiratory hazard if inhaled; handle it in a fume hood or with proper respiratory protection if necessary.

Applications of Acid-Metal Reactions

Industrial Uses

The reaction between acids and metals is fundamental in:

- Corrosion processes
- Metal extraction and purification
- Hydrogen production for fuel and industrial use

Educational Demonstrations

These reactions serve as excellent teaching tools for illustrating chemical principles such as redox reactions, stoichiometry, and gas evolution.

Conclusion

When a student adds 30.0 mL of 1.00 M HCl to 0.56 g of powdered iron, a chemical reaction occurs consistent with the equation:

- $Fe\ (s) + 2HCl\ (aq) \rightarrow FeCl_2\ (aq) + H_2\ (g)$

Calculations reveal that the amount of iron present limits the extent of the reaction, leading to the production of hydrogen gas and soluble iron(II) chloride. Understanding this process involves knowledge of molarity, stoichiometry, limiting reactants, and safety practices. This reaction exemplifies fundamental concepts in chemistry and highlights the practical applications of acid-metal interactions in industrial and educational contexts.

Frequently Asked Questions

What is the balanced chemical equation for the reaction between iron (Fe) and hydrochloric acid (HCl)?

The balanced equation is: $Fe(s) + 2HCl(aq) \rightarrow FeCl_2(aq) + H_2(g)$.

How do you calculate the moles of HCl added to the reaction?

Use the molarity and volume: moles HCl = $1.00\ mol/L \times 0.030\ L = 0.030\ mol$.

How can I determine the number of moles of iron (Fe) in 0.56 g of powdered Fe?

Calculate moles of Fe: 0.56 g ÷ 55.85 g/mol ≈ 0.01004 mol.

Is the reaction between Fe and HCl a redox reaction?

Yes, iron is oxidized from 0 to +2 oxidation state, and hydrogen ions are reduced from +1 to H_2 gas, making it a redox reaction.

What is the limiting reagent in this reaction?

Since 0.030 mol of HCl is added and only about 0.01004 mol of Fe is present, Fe is the limiting reagent.

How much hydrogen gas (H_2) is produced in this reaction?

The amount of H_2 generated is equal to the moles of Fe, which is approximately 0.01004 mol, producing about 0.01004 mol H_2.

How do you determine the mass of Fe reacted in this process?

Since Fe is limiting and all of it reacts, the mass is 0.01004 mol × 55.85 g/mol ≈ 0.561 g, but only 0.56 g was available, so all reacts.

What are the practical applications of this reaction in industries?

This reaction is used for iron purification, production of hydrogen gas, and in laboratory demonstrations of redox chemistry.

How does the concentration of HCl influence the reaction extent?

Higher HCl concentration or volume increases the amount of HCl available, potentially producing more H_2 gas if excess Fe is present; however, here Fe limits the reaction.

What safety precautions should be taken when performing this reaction in the lab?

Handle HCl with gloves and eye protection, perform the reaction in a well-ventilated area or fume hood, and be cautious with hydrogen gas, which is flammable.

Additional Resources

When A Student Adds 30.0 mL Of 1.00 M HCl To 0.56 g Of Powdered Fe, A Reaction Occurs According To The Equation — this scenario offers a classic illustration of acid-metal reactions, stoichiometry, and chemical calculations fundamental to introductory chemistry. Whether you're a student seeking clarity on the reaction process or a curious enthusiast eager to understand how quantitative analysis unfolds in practice, this guide will walk you through each step with detailed explanations, calculations, and insights.

Introduction: Understanding the Scenario

Imagine a student in a laboratory setting preparing to observe a reaction between iron powder and hydrochloric acid. The student carefully measures 30.0 mL of 1.00 M HCl and adds it to 0.56 g of powdered iron (Fe). The question arises: What chemical reaction occurs? and what are the quantitative changes involved?

This scenario encapsulates the core principles of stoichiometry, acid-base reactions, and gas evolution, making it an excellent case study for understanding how to approach chemical reactions quantitatively.

The Key Chemical Equation: Iron and Hydrochloric Acid

The primary reaction between iron metal and hydrochloric acid is a typical single displacement reaction, where iron displaces hydrogen from the acid, producing iron(II) chloride and hydrogen gas.

Balanced Chemical Equation:

$$\mathrm{Fe(s) + 2HCl(aq) \rightarrow FeCl_2 (aq) + H_2 (g)}$$

This equation indicates that:

- One mole of iron reacts with two moles of hydrochloric acid.
- The products are iron(II) chloride ($FeCl_2$) in solution and hydrogen gas (H_2).

Understanding this reaction provides the foundation for analyzing how much iron reacts, how much acid is consumed, and how much hydrogen gas is produced.

Step 1: Calculating Moles of Hydrochloric Acid

The student uses 30.0 mL of 1.00 M HCl. To understand how much acid is present:

Moles of HCl:

$$\text{Moles of HCl} = \text{Concentration} \times \text{Volume}$$

- Convert volume to liters:

$$30.0\, \text{mL} = 0.0300\, \text{L}$$

- Calculate:

$$1.00\, \text{mol/L} \times 0.0300\, \text{L} = 0.0300\, \text{mol}$$

Result: The reaction mixture contains 0.0300 mol of HCl.

Step 2: Calculating Moles of Iron Powder

Next, determine how many moles of iron are present:

Molar mass of iron (Fe):
$$ \mathrm{Fe} = 55.85\, \text{g/mol} $$

Moles of Fe:
$$ \text{Moles of Fe} = \frac{\text{mass}}{\text{molar mass}} = \frac{0.56\, \text{g}}{55.85\, \text{g/mol}} \approx 0.0100\, \text{mol} $$

Result: The powder contains approximately 0.0100 mol of Fe.

Step 3: Comparing Reactant Amounts and Determining the Limiting Reactant

The balanced equation shows a 2:1 molar ratio of HCl to Fe:

- For every 1 mol of Fe, 2 mol of HCl are needed.
- For 0.0100 mol Fe, the amount of HCl required is:

$$ 0.0100\, \text{mol Fe} \times 2 = 0.0200\, \text{mol HCl} $$

The student has 0.0300 mol HCl, which exceeds the 0.0200 mol needed for complete reaction with all the Fe.

Conclusion:
- Iron (Fe) is the limiting reactant because it will be fully consumed before the acid.
- Hydrochloric acid (HCl) is in excess.

Step 4: Determining the Extent of the Reaction

Since Fe is limiting, all 0.0100 mol of Fe will react:

Moles of hydrogen gas produced:
From the balanced equation, 1 mol Fe produces 1 mol H_2.

$$ \text{Moles of H}_2 = 0.0100\, \text{mol} $$

Moles of $FeCl_2$ formed:
Similarly, 1 mol Fe produces 1 mol $FeCl_2$:

$$ \text{Moles of FeCl}_2 = 0.0100\, \text{mol} $$

Step 5: Quantitative Insights and Gas Volume Calculation

Hydrogen Gas Volume:
At standard temperature and pressure (STP), 1 mol of gas occupies approximately 22.4 L.

\[V_{H_2} = 0.0100\, \text{mol} \times 22.4\, \text{L/mol} = 0.224\,

\text{L} \]

Result: Approximately 224 mL of hydrogen gas will be evolved during the reaction.

Remaining HCl:
- Initial HCl: 0.0300 mol
- Consumed: 0.0200 mol
- Remaining: 0.0100 mol

This excess HCl remains in solution, unreacted, after the iron is fully consumed.

Additional Considerations and Practical Implications

Reaction Completeness:
- The reaction proceeds until all the limiting reagent (iron) is used.
- Excess HCl remains in solution and can be recovered or neutralized.

Gas Collection:
- Hydrogen gas can be collected over water or in a sealed container.
- Safety precautions are essential, as hydrogen is flammable.

Observations:
- Bubbles of hydrogen gas are visible during the reaction.
- The solution turns a pale green or colorless, depending on the iron salt formed.

Step 6: Broader Applications and Conceptual Takeaways

Understanding Stoichiometry:
This experiment exemplifies the importance of mole ratios and limiting reactants in predicting reaction outcomes.

Practical Skills:
- Accurate measurement of reactants.
- Correct unit conversions.
- Use of stoichiometry to predict products and gas volumes.

Real-World Context:
Reactions like these are fundamental in metal processing, corrosion studies, and laboratory syntheses.

Summary: Key Points to Remember

- The reaction between powdered iron and hydrochloric acid produces hydrogen gas and iron(II) chloride.
- Calculations involve converting volumes to moles, applying mole ratios, and using molar volumes for gases.
- Iron is the limiting reagent; excess acid remains unreacted.
- Approximately 224 mL of hydrogen gas is expected at STP from the complete reaction of 0.0100 mol of Fe.
- Such analyses reinforce the importance of stoichiometry and careful

measurement in chemical reactions.

Final Thoughts

Understanding "When A Student Adds 30.0 mL Of 1.00 M HCl To 0.56 g Of Powdered Fe, A Reaction Occurs According To The Equation" involves more than just balancing equations; it requires integrating concepts of molarity, limiting reagents, gas laws, and reaction kinetics. Mastery of these principles empowers you to predict product formation, gas evolution, and reaction efficiency—a cornerstone of both academic and industrial chemistry.

Happy experimenting!

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