MgCl2(aq)+H2(G) A) If 0.158 G Of Mg Reacts With Excess HCl In A Calorimeter Containing 100 ML Of Water,

MgCl2(aq)+H2(G) A) If 0.158 G Of Mg Reacts With Excess HCl In A Calorimeter Containing 100 ML Of Water,

Understanding the chemical reactions and energy changes involved in magnesium and hydrochloric acid interactions is essential in both academic and industrial contexts. When 0.158 grams of magnesium reacts with excess hydrochloric acid (HCl) in a calorimeter containing 100 mL of water, a series of chemical and thermodynamic processes occur, leading to measurable temperature changes and insights into enthalpy changes. This article explores the detailed mechanisms, calculations, and significance of this reaction.

Overview of the Reaction Between Magnesium and Hydrochloric Acid

The Chemical Equation

The fundamental reaction between magnesium metal and hydrochloric acid can be summarized as:

$$\mathrm{Mg (s)} + 2\, \mathrm{HCl (aq)} \rightarrow \mathrm{MgCl_2 (aq)} + \mathrm{H_2 (g)}$$

This reaction involves magnesium metal reacting with hydrochloric acid to produce magnesium chloride and hydrogen gas.

Significance of the Reaction

- Industrial applications: Production of magnesium salts and hydrogen gas.
- Educational purposes: Demonstrating acid-metal reactions and measuring enthalpy changes.
- Thermodynamic insights: Understanding energy released or absorbed during chemical reactions.

Experimental Setup and Conditions

Calorimeter and Water Volume

A calorimeter is used to measure the heat exchanged during the reaction, containing exactly 100 mL of water. The water acts as a medium for heat transfer, allowing for temperature measurements that reflect the energy change.

Mass of Magnesium Reacted

- Given mass: 0.158 g of magnesium.
- Molar mass of Mg: approximately 24.305 g/mol.
- Number of moles of Mg: Calculated as:

$$
\text{moles of Mg} = \frac{0.158\, \text{g}}{24.305\, \text{g/mol}} \approx 0.0065\, \text{mol}
$$

Excess Hydrochloric Acid

The reaction assumes an excess of HCl, ensuring complete reaction of magnesium. The amount of HCl is not limiting, simplifying calculations related to the reaction's thermodynamics.

Calculating the Heat Released or Absorbed

Understanding the Heat Transfer

- The temperature change of the water in the calorimeter reflects the heat released or absorbed during the reaction.
- Specific heat capacity of water: approximately 4.18 J/g°C.
- Mass of water: Since volume is 100 mL, assuming the density of water as 1 g/mL:

$$
\text{mass of water} = 100\, \text{g}
$$

Measuring Temperature Change

Suppose the initial temperature of the water is T_i, and after the reaction, it changes to T_f. The temperature change:

$$
\Delta T = T_f - T_i
$$

The heat exchanged:

$$
Q = m \times c \times \Delta T
$$

Where:
- $m = 100\, \text{g}$
- $c = 4.18\, \text{J/g°C}$

Thus,

$$
Q = 100 \times 4.18 \times \Delta T\, \text{J}
$$

The sign of Q indicates whether heat was released (exothermic, negative Q) or absorbed (endothermic, positive Q). For magnesium reacting with acid, the process is exothermic, releasing heat.

Calculating the Enthalpy Change per Mole of Magnesium

Standard Enthalpy Change of Reaction

The molar enthalpy change ($\Delta H_{\text{reaction}}$) can be calculated as:

$$
\Delta H = \frac{Q}{\text{moles of Mg}}
$$

Assuming the measured Q is the heat released during the reaction with 0.0065 mol of magnesium:

$$
\Delta H = \frac{Q}{0.0065\, \text{mol}}
$$

Expressed in kJ/mol:

$$
\Delta H (\text{kJ/mol}) = \frac{Q\, \text{(J)}}{1000 \times 0.0065}
$$

Sample Calculation

Suppose the temperature increase observed is 5°C:

$$
Q = 100 \times 4.18 \times 5 = 2090\, \text{J}
$$

Then,

$$
\Delta H = \frac{2090}{0.0065} \approx 321,538\, \text{J/mol} \approx 321.54\, \text{kJ/mol}
$$

\]

Since heat is released:

$$
\Delta H \approx -321.54\, \text{kJ/mol}
$$

This value indicates an exothermic process where magnesium releases approximately 321.54 kJ of energy per mole during the reaction.

Factors Affecting the Reaction and Measurement Accuracy

Temperature Measurement Precision

- Accurate temperature readings are crucial.
- Use of calibrated thermometers or digital temperature sensors improves reliability.

Calorimeter Calibration

- Ensuring the calorimeter's heat capacity is known or minimized.
- Correcting for heat losses to the environment.

Reaction Completeness

- Excess HCl ensures all Mg reacts.
- Stirring ensures uniform temperature distribution.

Purity of Magnesium

- Impurities can alter reaction enthalpy.
- Use high-purity magnesium for precise measurements.

Applications and Significance of the Data

Industrial Relevance

- Estimating energy requirements for magnesium processing.
- Designing reactors for hydrogen production.

Educational Importance

- Demonstrating principles of thermochemistry.
- Developing skills in calorimetric measurements and calculations.

Research and Development

- Understanding thermodynamic properties of metal-acid reactions.
- Developing new materials with tailored energetic profiles.

Conclusion

Understanding the thermodynamics of magnesium reacting with hydrochloric acid provides valuable insights into energy release during chemical reactions. By measuring temperature changes in a calorimeter, we can calculate the heat evolved or absorbed, leading to determination of the enthalpy change per mole of magnesium. Such experiments underpin many scientific and industrial applications, from energy efficiency assessments to materials engineering. Precise measurements, careful experimental setup, and thorough calculations are essential for accurate thermodynamic analysis, making this a fundamental concept in physical chemistry.

Keywords: magnesium hydrochloric acid reaction, calorimetry, enthalpy change, thermodynamics, chemical reaction energy, Mg reaction with HCl, calorimeter, heat transfer, molar enthalpy, exothermic reactions

Frequently Asked Questions

What is the chemical reaction between MgCl2(aq) and H2(g)?

The reaction involves magnesium reacting with hydrogen chloride to produce magnesium chloride and hydrogen gas, typically represented as $Mg + 2HCl \rightarrow MgCl_2 + H_2$.

How do you calculate the amount of hydrogen gas produced when 0.158 g of magnesium reacts?

First, find the molar mass of magnesium (24.305 g/mol), then calculate moles of Mg: 0.158 g / 24.305 g/mol. Since 1 mol Mg produces 1 mol H_2, this gives the moles of H_2 gas produced.

What is the significance of using a calorimeter in this reaction?

A calorimeter measures the heat change during the reaction, allowing us to determine the enthalpy change associated with the process.

How much hydrogen gas (in liters) is expected to be produced at standard conditions?

Calculate moles of Mg reacting, then use molar volume of gas (22.4 L/mol at STP). For example, if 1 mol Mg reacts, it produces 22.4 liters of H2 gas.

What is the role of water in this experiment involving Mg and HCl?

Water acts as the solvent in the calorimeter, facilitating the reaction and allowing measurement of temperature changes to determine heat transfer.

How do you determine the heat evolved or absorbed during the reaction?

Use the temperature change measured in the calorimeter, along with the water's specific heat capacity and mass, to calculate the heat change ($q = mc\Delta T$).

What assumptions are made when calculating the heat of reaction in this setup?

Assumptions include no heat loss to surroundings, the water's specific heat capacity remains constant, and the reaction occurs entirely within the calorimeter.

How does the reaction of magnesium with HCl relate to real-world applications?

This reaction models processes like metal corrosion, hydrogen production for fuel, and industrial manufacturing of magnesium compounds.

What safety precautions should be taken when conducting this reaction in a lab?

Wear appropriate protective gear, handle acids carefully, conduct the experiment in a well-ventilated area or fume hood, and be cautious with hydrogen gas, which is flammable.

How can the enthalpy change be calculated from the experimental data?

Measure the temperature change in water, calculate heat absorbed or released ($q = mc\Delta T$), and normalize by the moles of magnesium reacted to find ΔH per mole.

Additional Resources

Magnesium Chloride Reaction with Hydrogen Gas: An In-Depth Analysis of the Reaction Dynamics and Energy Changes

---

Introduction to the Magnesium and Hydrogen Interaction

In the realm of chemical reactions, the interaction between magnesium compounds and hydrogen is a subject of both academic interest and practical significance. Specifically, the reaction between magnesium chloride in aqueous solution, $MgCl_2(aq)$, and hydrogen gas, $H_2(g)$, exemplifies fundamental principles of chemical thermodynamics, reaction kinetics, and energy transfer. When a small quantity of magnesium reacts with excess hydrochloric acid (HCl) in a controlled environment—such as a calorimeter containing water—it provides a valuable window into enthalpy changes, reaction stoichiometry, and the behavior of aqueous salts in energy exchange processes.

In this article, we will analyze a scenario where 0.158 grams of magnesium (Mg) reacts with excess hydrochloric acid in a calorimeter containing 100 mL of water, with a focus on understanding the reaction mechanics, calculating the heat transfer, and exploring the implications of these findings.

Theoretical Background and Reaction Overview

Reactants and Their Properties

- Magnesium (Mg): A lightweight, moderately reactive alkaline earth metal, with a molar mass of approximately 24.305 g/mol. Magnesium tends to form ionic compounds and participates actively in displacement and combustion reactions.

- Hydrochloric Acid (HCl): A strong acid capable of reacting with metals like magnesium, producing hydrogen gas and soluble magnesium chloride.

- Hydrogen Gas (H_2): A diatomic molecule that is released during the reaction and can be measured or observed in laboratory setups to determine reaction progress and energy changes.

- Water (H_2O): Serves as the solvent in the calorimeter, providing a medium for the reaction and a means to measure temperature change.

Reaction Equation

The primary chemical reaction occurring in this scenario is:

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

This reaction is highly exothermic, meaning it releases heat into the surroundings, which can be measured indirectly via temperature change in the water.

Experimental Context and Assumptions

In the described scenario, a small amount of magnesium reacts with excess HCl, and the resultant heat is transferred to 100 mL of water in a calorimeter. Several assumptions are typically made to simplify calculations:

- The calorimeter is perfectly insulated, with no heat loss to surroundings.
- All heat generated by the reaction is absorbed by the water.
- The specific heat capacity of water is approximately 4.18 J/g°C.
- The initial temperature of water is recorded before the reaction begins.
- The magnesium reacts completely with the available acid.

Calculations and Analytical Approach

Step 1: Determine Moles of Magnesium Reacted

Given:

- Mass of Mg = 0.158 g
- Molar mass of Mg ≈ 24.305 g/mol

$$
\text{Moles of Mg} = \frac{0.158\, \text{g}}{24.305\, \text{g/mol}} \approx 0.0065\, \text{mol}
$$

This mole quantity is crucial for calculating the energy change per mole, which allows comparison with standard thermodynamic data.

Step 2: Understanding the Reaction Stoichiometry

For each mole of magnesium:

$$ \text{Mg} + 2 \text{HCl} \rightarrow \text{MgCl}_2 + \text{H}_2 $$

- 1 mol Mg produces 1 mol H_2 and consumes 2 mol HCl.
- Since HCl is in excess, the limiting reagent is magnesium.

Step 3: Energy Released (Heat of Reaction)

- The heat released (Q) during the reaction is absorbed by the water.
- The temperature change of the water (ΔT) is to be measured experimentally; since this is a theoretical review, we will demonstrate how to calculate it assuming a measured temperature change.

Suppose the temperature of water increased by ΔT degrees Celsius (°C):

$$
Q = m_{water} \times c_{water} \times \Delta T
$$

Where:

- $m_{water} = 100\, \text{mL} \times 1\, \text{g/mL} = 100\, \text{g}$
- $c_{water} = 4.18\, \text{J/g°C}$

Thus:

$$
Q = 100\, \text{g} \times 4.18\, \text{J/g°C} \times \Delta T
$$

Once Q is known, the molar enthalpy change (ΔH) for the reaction can be calculated:

$$
\Delta H = \frac{Q}{\text{moles of Mg}}
$$

This provides the heat change per mole of magnesium reacting, a key thermodynamic parameter.

Implications of the Reaction and Energy Transfer

Thermodynamic Significance

The reaction of magnesium with hydrochloric acid is exothermic, releasing a significant amount of energy as hydrogen gas forms and magnesium chloride dissolves. The calculated ΔH value offers insights into:

- Reaction spontaneity: Negative enthalpy change indicates an exothermic and spontaneous process.
- Energy efficiency: Understanding heat production is vital in industrial applications, such as metal processing or hydrogen generation.

Practical Applications and Safety Considerations

- Hydrogen Production: This reaction exemplifies a method for generating hydrogen gas, which is increasingly important as a clean fuel.
- Chemical Safety: The exothermic nature necessitates careful handling, especially when scaling up reactions, to prevent thermal runaway or accidents.

Additional Factors and Variables to Consider

- Reaction Rate: Temperature, surface area of magnesium, and acid concentration influence how quickly the reaction proceeds.
- Heat Losses: In real experiments, some heat escapes, so actual temperature changes might be lower than theoretical predictions.
- Impurities and Water Quality: Impurities can affect reaction kinetics and thermodynamics.
- Calorimeter Calibration: Ensuring the calorimeter's accuracy is critical for precise measurements.

Conclusion: What This Reaction Reveals About Energy and Chemistry

The reaction between magnesium and hydrochloric acid in an aqueous environment exemplifies core principles of chemistry, thermodynamics, and energy transfer. By analyzing the heat released during the process—via temperature change in water—scientists can determine the enthalpy change associated with the reaction. These insights are not only academically enriching but have practical implications in fields like sustainable energy production, materials science, and chemical manufacturing.

Understanding the detailed mechanics of such reactions helps optimize industrial processes, improve safety protocols, and deepen our appreciation for the energetic underpinnings of everyday chemical phenomena. Whether used for hydrogen generation or educational demonstrations, this reaction remains an excellent model for exploring the interplay between chemical change and energy flow.

In summary, analyzing the reaction of 0.158 g of magnesium with excess HCl in a calorimeter underscores the importance of thermodynamic principles in real-world chemical processes. The combination of stoichiometry, heat transfer calculations, and practical considerations forms a comprehensive picture of how energy is stored, released, and measured in chemical reactions—making it a fundamental and fascinating aspect of modern chemistry.

Mgcl2 Aq H2 G A If 0 158 G Of Mg Reacts With Excess Hcl In A Calorimeter Containing 100 Ml Of Water

Mgcl2 Aq H2 G A If 0 158 G Of Mg Reacts With Excess Hcl In A Calorimeter Containing 100 Ml Of Water

Related Articles

- Mr. Ferarra Is Planning A Field Trip To The History Museum For All Of The Students At His Middle School.
- Suppose An Economy Is Producing Real GDP Of $300 Billion. The Potential Output Is Equal To $400 Billion,
- It Seemed To Turner Less And Less Likely That He Would Be Lighting Out For The Territories Anytime Soon.

Back to Home