If 16.4 Kg Of Al2O3(s), 56.4 Kg Of NaOH(l), And 56.4 Kg Of HF(g) React Completely, How Many Kilograms

If 16.4 Kg Of Al2O3(s), 56.4 Kg Of NaOH(l), And 56.4 Kg Of HF(g) React Completely, How Many Kilograms of products are formed? This question involves understanding the chemical reactions among aluminum oxide (Al_2O_3), sodium hydroxide (NaOH), and hydrofluoric acid (HF). Calculating the mass of resulting compounds requires a solid grasp of stoichiometry, chemical equations, and molar mass conversions. In this article, we will explore the process step by step, providing clarity on how to approach such chemical calculations, and offering insights into the reaction mechanisms involved.

Understanding the Chemical Reactions Involved

1. The Reactants and Their Roles

- Aluminum Oxide (Al_2O_3): A basic oxide that reacts with acids or bases under certain conditions.
- Sodium Hydroxide (NaOH): A strong base capable of reacting with acids and metal oxides.
- Hydrofluoric Acid (HF): A weak acid with unique reactivity, especially with metal oxides and silicates.

2. Possible Chemical Reactions

The key reaction here involves aluminum oxide reacting with sodium hydroxide and hydrofluoric acid to form soluble aluminum fluoride complexes or other products.

One primary reaction pathway is:

$Al_2O_3 + 6\ NaOH + 6\ HF \rightarrow 2\ Na_3[AlF_6] + 3\ H_2O$

However, the actual reaction may involve multiple steps and side reactions, especially considering the quantities and physical states of reactants.

Note: For simplicity, this calculation assumes the formation of sodium hexafluoroaluminate ($Na_3[AlF_6]$) as the main product when Al_2O_3 reacts with NaOH and HF.

Calculating Moles of Reactants

1. Molar Masses of Reactants

- Al_2O_3:
$(2 \times 26.98) + (3 \times 16.00) = 53.96 + 48.00 = 101.96\, g/mol$

- NaOH:
$22.99 + 16.00 + 1.008 = 39.998\, g/mol$

- HF:
$1.008 + 18.998 = 20.006\, g/mol$

2. Moles of Each Reactant

- Al_2O_3:
$\frac{16,400\, g}{101.96\, g/mol} \approx 160.88\, mol$

- NaOH:
$\frac{56,400\, g}{39.998\, g/mol} \approx 1410.53\, mol$

- HF:
$\frac{56,400\, g}{20.006\, g/mol} \approx 2820.00\, mol$

Note: These calculations provide the basis for determining limiting reactants and product yields.

Determining the Limiting Reactant

1. Reaction Stoichiometry

Based on the simplified reaction:

$Al_2O_3 + 6\ NaOH + 6\ HF \rightarrow$ Products

- For each mole of Al_2O_3:
- 6 moles of NaOH are required
- 6 moles of HF are required

2. Comparing Available Moles to Requirements

- NaOH needed for 160.88 mol Al_2O_3:
$160.88 \times 6 = 965.28\, mol$

- HF needed for 160.88 mol Al_2O_3:
$160.88 \times 6 = 965.28\, mol$

- Available vs. Needed:
- NaOH: 1410.53 mol available, more than needed → Not limiting
- HF: 2820.00 mol available, more than needed → Not limiting
- Al_2O_3: 160.88 mol available, the limiting reactant since excess NaOH and HF are present

Thus, Al_2O_3 is the limiting reactant.

Calculating the Mass of Product Formed

1. Moles of Product Formed

Given the reaction, 2 mol $Na_3[AlF_6]$ are formed per 1 mol Al_2O_3.

- Moles of $Na_3[AlF_6]$:
$160.88\, mol\, Al_2O_3 \times \frac{2\, mol\, Na_3[AlF_6]}{1\, mol\, Al_2O_3} = 321.76\, mol$

2. Molar Mass of Sodium Hexafluoroaluminate ($Na_3[AlF_6]$)

- Na: 22.99 g/mol

- Al: 26.98 g/mol

- F: 18.998 g/mol

Calculate:

$$
(3 \times 22.99) + 26.98 + (6 \times 18.998) = 68.97 + 26.98 + 113.99 = 209.94\, g/mol
$$

\]

3. Mass of $Na_3[AlF_6]$ Formed

- Mass:
$321.76\, mol \times 209.94\, g/mol \approx 67,592\, g$

- Convert to Kilograms:
$67,592\, g \div 1000 = 67.59\, kg$

Therefore, approximately 67.59 kg of sodium hexafluoroaluminate are produced when 16.4 kg of Al_2O_3 fully reacts with excess NaOH and HF.

Considerations on Remaining Reactants and Byproducts

1. Excess Reactants

- Since NaOH and HF are in excess, they are not limiting, and their leftover quantities can be calculated if needed.
- The reaction consumes all of the Al_2O_3, producing the calculated product mass.

2. Water and Other Byproducts

- The reaction also produces water (H_2O), which can be calculated based on stoichiometry.
- For every 1 mol Al_2O_3 reacted, 3 mol H_2O are formed.

3. Total Mass of Products and Byproducts

- Sum of all products (primarily $Na_3[AlF_6]$) and byproducts (water) can be computed to verify mass balance.

Mass balance check:

- Reactants total mass:
16.4 kg (Al_2O_3) + 56.4 kg (NaOH) + 56.4 kg (HF) = 129.2 kg

- Products total mass:
Approximately 67.59 kg ($Na_3[AlF_6]$) + water + any minor byproducts.

This indicates that some mass remains unaccounted for in the simplified model, highlighting the importance of considering all byproducts and reaction pathways in real-world calculations.

Summary and Practical Implications

- When 16.4 kg of Al_2O_3, 56.4 kg of NaOH, and 56.4 kg of HF react completely, the main product formed is sodium hexafluoroaluminate ($Na_3[AlF_6]$).

- The mass of this product is approximately 67.59 kg based on stoichiometric calculations.
- The actual yield may vary due to physical factors, purity of reactants, and side reactions.
- Understanding these calculations is vital in industrial processes such as aluminum refining, chemical manufacturing, and waste treatment.

Final Thoughts on Chemical Calculations and Reaction Efficiency

Accurate stoichiometric calculations are essential in chemical engineering and laboratory settings. By determining limiting reactants and applying molar mass conversions, chemists can predict product yields and optimize processes. When dealing with complex reactions involving multiple reactants and products, breaking down the problem into manageable steps ensures clarity and precision.

Whether you're designing a chemical process or simply curious about the mass relationships in chemical reactions, mastering these calculations empowers you to understand and predict chemical behavior effectively.

In conclusion, if 16.4 kg of Al_2O_3, 56.4 kg of NaOH, and 56.4 kg of HF react completely, approximately 67.59 kilograms of sodium hexafluoroaluminate are produced, showcasing the importance of stoichiometry in real-world chemical reactions.

Frequently Asked Questions

What is the total mass of products formed when 16.4 kg of Al_2O_3, 56.4 kg of NaOH, and 56.4 kg of HF react completely?

The total mass of products equals the sum of all reactants, which is 16.4 kg + 56.4 kg + 56.4 kg = 129.2 kg, assuming no gases escape and complete reaction.

How do you determine the limiting reactant among Al_2O_3, NaOH, and HF in this reaction?

You compare the molar ratios of each reactant based on the balanced chemical equation to identify which reactant limits the reaction, by converting masses to moles and analyzing their ratios.

What is the balanced chemical equation for the reaction among Al_2O_3, NaOH, and HF?

A typical balanced reaction could be: $Al_2O_3 + 6\ NaOH + 6\ HF \rightarrow 2\ Na_3AlF_6 + 3\ H_2O$, but actual products depend on specific reaction conditions.

How do you convert the given masses of reactants to moles for stoichiometric calculations?

Divide each mass by its molar mass: Al_2O_3 (101.96 g/mol), NaOH (40.00 g/mol), and HF (20.01 g/mol) to find the number of moles for each reactant.

If all reactants react completely, how do you calculate the mass of each product formed?

Use the mole ratios from the balanced equation to determine the moles of products formed from the limiting reactant, then convert moles back to mass using their molar masses.

Why is it important to identify the limiting reactant in this reaction?

Identifying the limiting reactant allows you to determine the maximum amount of products formed and the leftover reactants, ensuring accurate yield predictions.

Additional Resources

If 16.4 Kg Of Al_2O_3(s), 56.4 Kg Of NaOH(l), And 56.4 Kg Of HF(g) React Completely, How Many Kilograms — this intriguing question touches upon fundamental concepts in chemical stoichiometry, reaction

completeness, and practical applications in industrial chemistry.
Understanding how these quantities interact in a chemical reaction not only illuminates the underlying principles of chemical calculations but also provides insight into real-world processes such as alumina processing, waste treatment, and chemical manufacturing. In this article, we will analyze the reaction involving aluminum oxide (Al_2O_3), sodium hydroxide (NaOH), and hydrofluoric acid (HF), determine the limiting reagent, and ultimately calculate the amount of product formed or residual reactants. This comprehensive review aims to clarify the concepts involved and guide readers through the step-by-step process of chemical quantification.

Understanding the Reactants and Their Reactions

Before delving into calculations, it is essential to comprehend the chemical nature of each reactant and their potential reactions under complete conditions.

Aluminum Oxide (Al_2O_3)

- Properties: A stable, amphoteric oxide, commonly encountered in bauxite ore, used extensively in aluminum production.
- Molecular weight: 101.96 g/mol.
- Role in reactions: Reacts with bases and acids to form different

compounds.

Sodium Hydroxide (NaOH)

- Properties: A strong base, highly soluble in water.
- Molecular weight: 40.00 g/mol.
- Role: Reacts with acids and amphoteric oxides to form soluble salts.

Hydrofluoric Acid (HF)

- Properties: A weak, yet highly toxic acid capable of attacking glass and metals.
- Molecular weight: 20.01 g/mol.
- Role: Reacts with oxides and metals, often forming fluorides.

Possible Reaction Pathways

Given the reactants, the most plausible reaction involves the formation of sodium aluminum fluoride, which is a common product in processing alumina with fluoride sources.

The core reaction can be considered as:

$$ \text{Al}_2\text{O}_3 + 6 \text{HF} \rightarrow 2 \text{AlF}_3 + 3 \text{H}_2\text{O} $$

However, in the presence of NaOH, the reaction pathway becomes more complex, often leading to soluble sodium aluminate and aluminum fluoride compounds.

A typical reaction sequence is:

1. Formation of sodium aluminate:

$$ \text{Al}_2\text{O}_3 + 2 \text{NaOH} + 3 \text{H}_2\text{O} \rightarrow 2 \text{NaAl(OH)}_4 $$

2. Reaction with HF to produce aluminum fluoride:

$$ \text{NaAl(OH)}_4 + 3 \text{HF} \rightarrow \text{AlF}_3 + \text{NaF} + 4 \text{H}_2\text{O} $$

Alternatively, directly reacting Al_2O_3 with NaOH and HF can produce complex fluorides and sodium aluminates.

Note: Since the question states "react completely," it is assumed the reaction proceeds to completion, consuming all limiting reactants.

Calculating the Moles of Reactants

The first step in any stoichiometric analysis is to convert given masses into moles.

1. Aluminum oxide (Al_2O_3):

$$\text{Mass} = 16.4 \text{ kg} = 16,400 \text{ g}$$

$$\text{Moles of Al}_2\text{O}_3 = \frac{16,400 \text{ g}}{101.96 \text{ g/mol}} \approx 160.96 \text{ mol}$$

2. Sodium hydroxide (NaOH):

$$\text{Mass} = 56.4 \text{ kg} = 56,400 \text{ g}$$

$$\text{Moles of NaOH} = \frac{56,400 \text{ g}}{40.00 \text{ g/mol}} = 1,410 \text{ mol}$$

3. Hydrofluoric acid (HF):

$$\text{Mass} = 56.4 \text{ kg} = 56,400 \text{ g}$$

$$\text{Moles of HF} = \frac{56,400 \text{ g}}{20.01 \text{ g/mol}} \approx 2,820 \text{ mol}$$

Determining the Limiting Reagent

To identify which reactant limits the reaction, compare the mole ratios from the balanced equations.

Considering the simplified reaction:

$$ \text{Al}_2\text{O}_3 + 6 \text{HF} \rightarrow 2 \text{AlF}_3 + 3 \text{H}_2\text{O} $$

- Stoichiometric ratio: 1 mol Al_2O_3 reacts with 6 mol HF.

Given:

- Al_2O_3: 160.96 mol
- HF: 2,820 mol

Calculate the required HF for 160.96 mol Al_2O_3:

$$ 160.96 \text{ mol} \times 6 = 965.76 \text{ mol} $$

Since 2,820 mol HF is available, and only 965.76 mol is needed for complete reaction with Al_2O_3, HF is in excess.

Next, compare NaOH:

The role of NaOH is to form sodium aluminate, which can react further with HF. Assuming complete reaction, the limiting reagent would likely be either NaOH or Al_2O_3, depending on the exact reaction pathway.

Suppose the main pathway involves:

$$ \text{Al}_2\text{O}_3 + 2 \text{NaOH} + 3 \text{H}_2\text{O} \rightarrow 2 \text{NaAl(OH)}_4 $$

From this:

- 1 mol Al_2O_3 requires 2 mol NaOH.

Calculate:

$$ 160.96 \text{ mol Al}_2\text{O}_3 \times 2 = 321.92 \text{ mol NaOH} $$

Available NaOH: 1,410 mol

Since 321.92 mol NaOH is required, and 1,410 mol are available, NaOH is in excess.

Conclusion:

- Limiting reagent: Al_2O_3 (since it requires fewer reactants relative to excess HF and NaOH).

Calculating the Product Mass

Assuming the main product is aluminum fluoride (AlF_3), formed from the reaction of Al_2O_3 and HF, the amount of AlF_3 produced can be determined.

Reaction:

$$ \text{Al}_2\text{O}_3 + 6 \text{HF} \rightarrow 2 \text{AlF}_3 + 3 \text{H}_2\text{O} $$

- 1 mol Al_2O_3 produces 2 mol AlF_3.

Total moles of AlF_3 produced:

$$ 160.96 \text{ mol} \times 2 = 321.92 \text{ mol} $$

Molecular weight of AlF_3:

$$ 26.98 (\text{Al}) + 3 \times 18.998 (\text{F}) = 26.98 + 56.994 = 83.974 \text{ g/mol} $$

Total mass of AlF_3:

$$ 321.92 \text{ mol} \times 83.974 \text{ g/mol} \approx 27,040 \text{ g} $$

$$\approx 27.04 \text{ kg}$$

Residual Reactants and Byproducts

Since Al_2O_3 is limiting, residual amounts of NaOH and HF remain:

- Unreacted NaOH:

$$1,410 - 321.92 \text{ mol} \times 2 = 1,410 - 643.84 = 766.16 \text{ mol}$$

Mass:

$$766.16 \text{ mol} \times 40.00 \text{ g/mol} \approx 30,646 \text{ g} = 30.65 \text{ kg}$$

- Unreacted HF:

$$2,820 - 6 \times 160.96 = 2,820 - 965.76 = 1,854.24 \text{ mol}$$

Mass:

$$1,854.24 \text{ mol} \times 20.01 \text{ g/mol} \approx 37,088 \text{ g} = 37.09 \text{ kg}$$

Summary:

- **Product (AlF_3): approximately 27.04 kg**
- **Residual NaOH: approximately 30.65 kg**
- **Residual HF: approximately 37.09 kg**

If 16 4 Kg Of Al2o3 S 56 4 Kg Of Naoh L And 56 4 Kg Of Hf G React Completely How Many Kilograms

If 16 4 Kg Of Al2o3 S 56 4 Kg Of Naoh L And 56 4 Kg Of Hf G React Completely How Many Kilograms

Related Articles

- It Is A Lawyers Duty To Act In A(n) ______________________ Fashion In Order To Protect The Interest Of
- Ind The Axis Of Symmetry For The Parabola Whose Equation Is Given. Use The Axis Of Symmetry To Find A
- In General, Countries That Were European Colonies In The 1940s Have __________. A. Lower-than-average

Back to Home