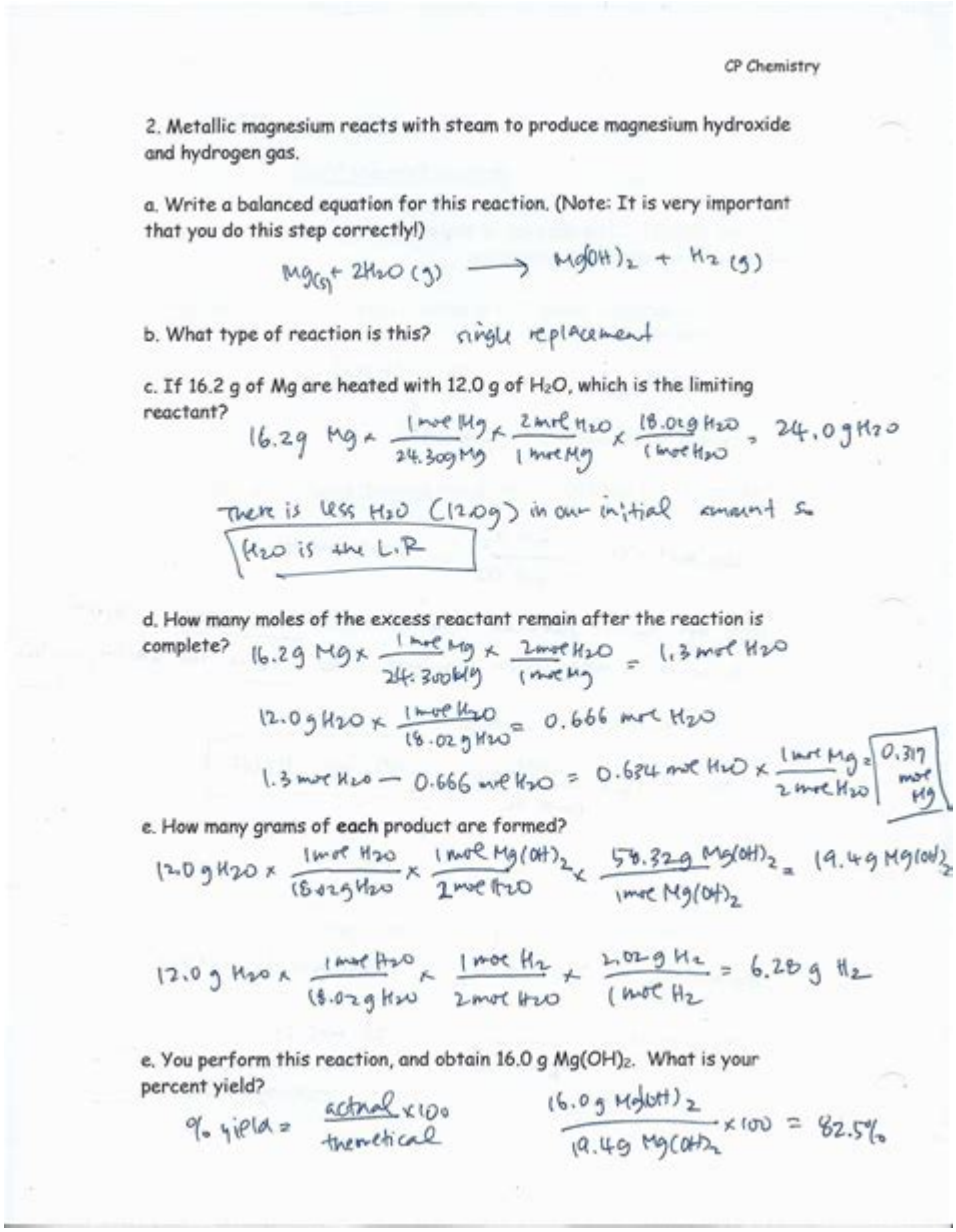
Chemistry Stoichiometry Problem Sheet 1



CP Chemistry

2. Metallic magnesium reacts with steam to produce magnesium hydroxide and hydrogen gas.

a. Write a balanced equation for this reaction. (Note: It is very important that you do this step correctly!)

$Mg_{(s)} + 2H_2O_{(g)} \longrightarrow Mg(OH)_2 + H_{2(g)}$

b. What type of reaction is this? single replacement

c. If 16.2 g of Mg are heated with 12.0 g of H_2O, which is the limiting reactant?

$16.2\,g\ Mg \times \frac{1\ mol\ Mg}{24.30\,g\ Mg} \times \frac{2\ mol\ H_2O}{1\ mol\ Mg} \times \frac{18.02\,g\ H_2O}{1\ mol\ H_2O} = 24.0\,g\ H_2O$

There is less H_2O (12.0g) in our initial amount so H_2O is the L.R

d. How many moles of the excess reactant remain after the reaction is complete?

$16.2\,g\ Mg \times \frac{1\ mol\ Mg}{24.30\,g\ Mg} \times \frac{2\ mol\ H_2O}{1\ mol\ Mg} = 1.3\ mol\ H_2O$

$12.0\,g\ H_2O \times \frac{1\ mol\ H_2O}{18.02\,g\ H_2O} = 0.666\ mol\ H_2O$

$1.3\ mol\ H_2O - 0.666\ mol\ H_2O = 0.634\ mol\ H_2O \times \frac{1\ mol\ Mg}{2\ mol\ H_2O} = 0.317\ mol\ Mg$

e. How many grams of **each** product are formed?

$12.0\,g\ H_2O \times \frac{1\ mol\ H_2O}{18.02\,g\ H_2O} \times \frac{1\ mol\ Mg(OH)_2}{2\ mol\ H_2O} \times \frac{58.32\,g\ Mg(OH)_2}{1\ mol\ Mg(OH)_2} = 19.4\,g\ Mg(OH)_2$

$12.0\,g\ H_2O \times \frac{1\ mol\ H_2O}{18.02\,g\ H_2O} \times \frac{1\ mol\ H_2}{2\ mol\ H_2O} \times \frac{2.02\,g\ H_2}{1\ mol\ H_2} = 6.28\,g\ H_2$

e. You perform this reaction, and obtain 16.0 g $Mg(OH)_2$. What is your percent yield?

$\%\ yield = \frac{actual}{theoretical} \times 100 \qquad \frac{16.0\,g\ Mg(OH)_2}{19.4\,g\ Mg(OH)_2} \times 100 = 82.5\%$

Chemistry Stoichiometry Problem Sheet 1 is an essential resource for students and educators aiming to grasp the intricate calculations related to chemical reactions. Stoichiometry is the branch of chemistry that deals with the quantitative relationships between the reactants and products in a chemical reaction. Understanding stoichiometry is fundamental for various applications, including predicting amounts of substances consumed and produced in reactions, determining yields, and performing analyses in laboratory settings. This article will explore the key concepts of stoichiometry, provide examples, and present problems that students can solve to enhance their understanding of the topic.

Understanding Stoichiometry

Stoichiometry derives its name from the Greek words "stoicheion," meaning element, and "metron,"

meaning measure. It is primarily based on the law of conservation of mass, which states that matter cannot be created or destroyed in a chemical reaction. Therefore, the total mass of reactants must equal the total mass of products.

Key Concepts in Stoichiometry

1. Mole Concept:
- A mole is a unit that measures the amount of substance. One mole contains 6.022×10^{23} entities (atoms, molecules, ions, etc.), known as Avogadro's number.
- The molar mass of a substance (in grams per mole) is the mass of one mole of that substance.

2. Balanced Chemical Equations:
- A balanced chemical equation represents a chemical reaction with equal numbers of each type of atom on both sides of the equation.
- Example: The combustion of methane can be represented as:
$$
CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O
$$
- Here, one molecule of methane reacts with two molecules of oxygen to produce one molecule of carbon dioxide and two molecules of water.

3. Mole Ratios:
- Mole ratios are derived from the coefficients of a balanced chemical equation and indicate the proportion of reactants and products involved in the reaction.
- From the equation above, the mole ratio of CH_4 to O_2 is 1:2, while the ratio of CH_4 to H_2O is 1:2.

4. Calculating Amounts:
- Stoichiometry allows for the calculation of reactants needed or products formed using mole ratios, molar masses, and the concept of the mole.

Stoichiometric Calculations

To perform stoichiometric calculations, follow these general steps:

1. Write a balanced chemical equation for the reaction.
2. Convert quantities of known substances (mass, volume, or number of particles) to moles using the molar mass or Avogadro's number.
3. Use mole ratios from the balanced equation to find the number of moles of the unknown substance.
4. Convert moles of the unknown back to the desired units (mass, volume, or number of particles).

Example Problems

To solidify understanding, here are a few example problems with solutions.

Example 1: Given the balanced equation for the reaction of aluminum with oxygen:
$$
4Al + 3O_2 \rightarrow 2Al_2O_3
$$
Calculate how many grams of Al_2O_3 can be produced from 10 grams of aluminum.

Solution:
1. Convert grams of Al to moles:
- Molar mass of Al = 26.98 g/mol.
$$
\text{Moles of } Al = \frac{10 \text{ g}}{26.98 \text{ g/mol}} \approx 0.370 \text{ moles}
$$

2. Use mole ratio to find moles of Al_2O_3:
- From the equation, $4 \text{ moles } Al$ produce $2 \text{ moles } Al_2O_3$.
$$
\text{Moles of } Al_2O_3 = 0.370 \text{ moles } Al \times \frac{2 \text{ moles } Al_2O_3}{4 \text{ moles } Al} = 0.185 \text{ moles } Al_2O_3
$$

3. Convert moles of Al_2O_3 to grams:
- Molar mass of Al_2O_3 = 101.96 g/mol.
$$
\text{Mass of } Al_2O_3 = 0.185 \text{ moles} \times 101.96 \text{ g/mol} \approx 18.86 \text{ g}
$$

Example 2: For the reaction of hydrochloric acid with sodium hydroxide:
$$
HCl + NaOH \rightarrow NaCl + H_2O
$$
How many grams of $NaCl$ can be produced from 50 mL of 0.5 M HCl?

Solution:
1. Calculate moles of HCl:
- Molarity (M) = moles/volume (L), so:
$$
\text{Moles of } HCl = 0.5 \text{ mol/L} \times 0.050 \text{ L} = 0.025 \text{ moles}
$$

2. Use the mole ratio:
- The reaction shows a 1:1 ratio, so moles of $NaCl$ produced = 0.025 moles.

3. Convert moles of $NaCl$ to grams:
- Molar mass of $NaCl$ = 58.44 g/mol.
$$
\text{Mass of } NaCl = 0.025 \text{ moles} \times 58.44 \text{ g/mol} \approx 1.46 \text{ g}
$$

Practice Problems

Here are a few practice problems for students to solve on their own:

1. Combustion of Propane: Given the balanced equation:
$$
C_3H_8 + 5O_2 \rightarrow 3CO_2 + 4H_2O
$$
If you have 10 moles of C_3H_8, how many moles of CO_2 will be produced?

2. Formation of Water:
$$
2H_2 + O_2 \rightarrow 2H_2O
$$
Calculate the mass of water produced when 2 grams of H_2 react completely.

3. Decomposition of Calcium Carbonate:
$$
CaCO_3 \rightarrow CaO + CO_2
$$
If you start with 50 grams of $CaCO_3$, how many grams of CO_2 will be produced?

Conclusion

Chemistry stoichiometry is an invaluable tool for scientists and students alike, providing the means to predict and quantify the results of chemical reactions. By mastering the concepts of moles, molar mass, balanced equations, and mole ratios, students can solve a range of problems, from simple calculations to complex laboratory analyses. The practice problems and examples presented in this article serve as a foundation for further exploration of stoichiometry and its applications in real-world scenarios. With diligent practice, students can become proficient in stoichiometric calculations, enabling them to tackle more advanced topics in chemistry with confidence.

Frequently Asked Questions

What is the purpose of a stoichiometry problem sheet in chemistry?

A stoichiometry problem sheet is designed to help students practice and understand the quantitative relationships between reactants and products in chemical reactions, allowing them to calculate amounts of substances involved.

How do you balance a chemical equation before solving

stoichiometry problems?

To balance a chemical equation, adjust the coefficients in front of the reactants and products until the number of atoms of each element is equal on both sides of the equation.

What is the significance of the mole ratio in stoichiometry?

The mole ratio, derived from the coefficients of a balanced equation, is crucial for converting between moles of reactants and products, allowing for accurate calculations in stoichiometry.

Can you explain how to use dimensional analysis in stoichiometry?

Dimensional analysis involves using conversion factors to cancel out units and convert quantities from one substance to another, ensuring that all calculations in stoichiometry are accurate and consistent.

What are common mistakes students make when solving stoichiometry problems?

Common mistakes include failing to balance the equation, using incorrect mole ratios, miscalculating conversions, or neglecting the units throughout the calculations.

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