

Stoichiometry: Mole Ratios

Task

Introduction of the Problem/Context: In this activity, high school chemistry students carry out class experiments in pairs; where they investigate the reaction between Zinc and Hydrochloric acid. From the observations and results, they formulate stoichiometric chemical equations and work out mole ratios for the reacting substances and their products.

Selected GPS:

Co-Requisite: Characteristics of Science

Habits of Mind

- **SCSh2:** Students will use standard safety practices for all classroom laboratory and field investigations.
 - a. Follow correct procedures for use of scientific apparatus.
 - b. Demonstrate appropriate techniques in all laboratory situations.
- **SCSh3:** Students will identify and investigate problems scientifically.
 - a. Suggest reasonable hypotheses for identified problems.
 - b. Develop procedures for solving scientific problems.
 - c. Collect, organize and record appropriate data.
 - e. Develop reasonable conclusions based on data collected.
- **SCSh4:** Students will use tools and instruments for observing, measuring, and manipulating scientific equipment and materials.
 - a. Develop and use systematic procedures for recording and organizing information.

Nature of Science

- **SCSh7:** Students will analyze how scientific knowledge is developed.
Students recognize that:
 - e. Testing, revising, and occasionally rejecting new and old theories never ends.

Co-Requisite: Characteristics of Science

Content

- **SC2:** Students will relate how the Law of Conservation of Matter is used to determine chemical composition in compounds and chemical reactions.
 - a. Identify and balance the following types of chemical equations:
 - Synthesis
 - Decomposition
 - Single Replacement
 - Double Replacement
 - Combustion

- b. Experimentally determine indicators of a chemical reaction specifically precipitation, gas evolution, water production, and changes in energy to the system.
 - d. Identify and solve different types of stoichiometry problems, specifically relating mass to moles and mass to mass.
- **SC3:** Students will use the modern atomic theory to explain the characteristics of atoms.
 - e. Compare and contrast types of chemical bonds (i.e. ionic, covalent).

Classroom Materials: Lesson Outline

Stoichiometry: Mole Ratios

Grade Level/Subject: High School Chemistry

Overview: In this activity, high school chemistry students carry out a class experiment in pairs, where they investigate the reaction between Zinc and Hydrochloric acid. From the observations and results, they formulate stoichiometric chemical equations and work out mole ratios for the reacting substances and their products.

Key Objectives:

- To investigate a problem scientifically (GPS: SCSH2 a, b).
- To suggest reasonable explanations based of data collected (GPS: ScSh3 e).
- To keep detailed and accurate records of data collected (GPS: SCSH4 a).
- To understand and analyze how scientific knowledge is developed (GPS: SCSH7 e).

Learning Outcomes:

- By the end of the activities in the unit, students will be able to:
 1. Predict the products formed when Zinc reacts with Hydrochloric acid.
 2. Derive mole ratios from stoichiometric chemical equations.
 3. Describe the characteristics that signify the evidence of a chemical reaction.
 4. Explain why some substances (metals) would not react with Hydrochloric acid under the same conditions.

Possible Materials:

- | | |
|----------------------------|--------------------------------|
| • Test-tubes | • Zinc granules |
| • Test-tube holder | • Protective eyewear |
| • Stirring Rods | • Protective eyewear (Goggles) |
| • 100ml graduated cylinder | • Aprons |
| • Matches | • Gloves (optional) |
| • 2M Hydrochloric acid | • Tweezers |

Task:

Students are required to conduct an experiment (while exercising appropriate safety precautions), which involves a reaction between a strong acid and a metal. They are expected to make careful observations in order to determine the evidence of a chemical reaction and use the observations as basis for formulating chemical a equation for the reaction from which mole ratios of the reacting species and their products are derived.

Procedure

- Reacting Zinc granules and 2M Hydrochloric acid: Some Zinc granules are placed in a test tube using a pair of tweezers. 10 ml of Hydrochloric acid then carefully poured into the test-tube. The mixture is allowed to react for about a minute and then a lit matchstick held over the mouth of the test-tube which should be tilted at an angle and pointed away from other students.

[CAUTION: *Hydrochloric acid is corrosive and should be handled with care. Protective eyewear (goggles) and aprons should be worn at all times during the experiment. Hydrogen gas is explosive when mixed with air and should only be prepared in small quantities.*]

Sample Questions:

- What properties of the reacting substances made it possible for the reaction to take place?
- What would happen if Copper metal was used instead of zinc metal?
- Suppose 1M Hydrochloric acid was used instead, how would this affect time taken for the reaction to be completed?
- What would happen if the reaction mixture was warmed during the reaction? Why?

Analysis

1. In this experiment, what are the possible products based on the reacting substances?
2. From your observations, what can be done to ensure that all the acid has reacted?
3. Make a prediction about the kind of bonds that would be formed in the products of the reaction between Zinc and Hydrochloric acid.
4. Explain the observations that provided clear evidence that a reaction took place.

Assessment Ideas:

- Teacher reflection: are the objectives being achieved. Is there evidence for this?
- Get students to write a detailed laboratory report that summarizes the experimental procedure, the observations and conclusions/explanations that they drew from the data.
- Student journals/laboratory notebooks for experimental observations: is there evidence of learning? Are their observations consistent with universal scientific principles?
- Teacher-constructed tests and quizzes based on mole ratios and stoichiometry.

Extension Ideas:

- Allow students to predict the products of other chemical reactions involving various other substances, which cannot be conducted safely under laboratory conditions.
- Have students think about modifications in the experimental set-up that may result in changes in the mode of reaction without altering the products.

Sample Question for Further Discussion

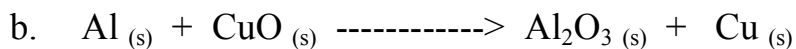
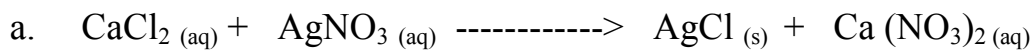
1. Balance the following chemical equations

- $\text{PH}_3 (g) + \text{O}_2 (g) \text{-----} \rightarrow \text{P}_4\text{O}_{10} (s) + \text{H}_2\text{O} (l)$
- $\text{Ca}(\text{OH})_2 (aq) + \text{H}_3\text{PO}_4 (aq) \text{-----} \rightarrow \text{H}_2\text{O} (g) + \text{Ca}_3(\text{PO}_4)_2 (s)$
- $\text{PbO} (s) + \text{CH}_3\text{COOH} (aq) \text{-----} \rightarrow \text{Pb}(\text{CH}_3\text{COO})_2 (aq) + \text{H}_2\text{O} (l)$

2. Classify the following reactions using single replacement (SR), Double replacement (DR), Decomposition (D), Neutralization (N), Combustion (C) or synthesis (S).

- $(\text{NH}_4)_2\text{CO}_3 (s) \text{-----} \rightarrow 2\text{NH}_3 (g) + \text{CO}_2 (g) + \text{H}_2\text{O} (g)$
- $\text{H}_2\text{SO}_4 (aq) + 2\text{NaOH} (aq) \text{-----} \rightarrow \text{Na}_2\text{SO}_4 (aq) + 2\text{H}_2\text{O} (l)$
- $\text{Mg} (s) + 2\text{HCl} (aq) \text{-----} \rightarrow \text{MgCl}_2 (aq) + \text{H}_2 (g)$
- $2\text{C}_4\text{H}_{10} (g) + 13\text{O}_2 (g) \text{-----} \rightarrow 8\text{CO}_2 (g) + 10\text{H}_2\text{O} (g)$

3. **Balance the following chemical equations and work out all the mole ratios for the reactants and products in each case.**



4. **17.24g of liquid Hexane (C₆H₁₄) were reacted completely with 1.90 moles of oxygen gas (O₂).**

a. What are the products of this chemical reaction?

b. Write a balanced chemical equation for the reaction and the mole ratio (reaction ratio) between Hexane and Oxygen.

c. On the basis of the mole ratios obtained in (a) above, find the number of moles of Hexane that reacted.