

grahams law worksheet with answers

Graham's Law worksheet with answers is an essential learning tool for students studying the principles of gas diffusion and effusion in chemistry. This law quantitatively describes how the rates of diffusion or effusion of gases relate to their molar masses. Understanding Graham's Law is crucial for students pursuing chemistry and related fields, as it lays the foundation for more advanced topics in gas behavior. This article provides an overview of Graham's Law, a sample worksheet with various problems, and detailed answers to help students grasp the concept effectively.

Understanding Graham's Law

Graham's Law states that the rate of diffusion or effusion of a gas is inversely proportional to the square root of its molar mass. In simpler terms, lighter gases diffuse or effuse faster than heavier gases. The mathematical expression of Graham's Law is given by:

$$\frac{\text{Rate}_1}{\text{Rate}_2} = \sqrt{\frac{\text{Molar Mass}_2}{\text{Molar Mass}_1}}$$

Where:

- Rate_1 and Rate_2 are the rates of diffusion or effusion of gas 1 and gas 2, respectively.
- Molar Mass_1 and Molar Mass_2 are the molar masses of gas 1 and gas 2, respectively.

Application of Graham's Law

Graham's Law is widely applied in various fields, including:

- Chemical Engineering: Understanding how different gases behave under various conditions.
- Environmental Science: Analyzing the diffusion of pollutants in the atmosphere.
- Laboratory Settings: Gaining insights into gas behavior during experiments.

Sample Worksheet on Graham's Law

Below is a sample worksheet designed to test the understanding of Graham's Law. Students are encouraged to solve the problems before checking the answers provided at the end.

Worksheet Problems

1. Problem 1: Calculate the rate of effusion of helium (He) compared to neon (Ne). The molar mass of helium is 4 g/mol, and the molar mass of neon is 20 g/mol.
2. Problem 2: If the rate of diffusion of gas A is 3.0 L/min, and the molar mass of gas A is 16 g/mol, find the rate of diffusion of gas B, which has a molar mass of 32 g/mol.
3. Problem 3: Two gases, ammonia (NH₃) and hydrogen chloride (HCl), are allowed to effuse through a small hole. The molar mass of ammonia is 17 g/mol, and the molar mass of hydrogen chloride is 36.5 g/mol. Calculate the ratio of the rates of effusion of ammonia to hydrogen chloride.
4. Problem 4: A gas with a molar mass of 44 g/mol diffuses at a rate of 2.5 L/min. What would be the rate of diffusion of a gas with a molar mass of 28 g/mol?
5. Problem 5: If the rate of effusion of gas X is twice that of gas Y, and the molar mass of gas Y is 18 g/mol, what is the molar mass of gas X?

Answers to the Worksheet Problems

Now, let's go through the answers and explanations for each problem step by step.

Answer 1

To calculate the rate of effusion of helium compared to neon, we use Graham's Law:

$$\sqrt{\frac{\text{Rate}_{\text{He}}}{\text{Rate}_{\text{Ne}}}} = \sqrt{\frac{\text{Molar Mass}_{\text{Ne}}}{\text{Molar Mass}_{\text{He}}}}$$

Substituting the values:

$$\sqrt{\frac{\text{Rate}_{\text{He}}}{\text{Rate}_{\text{Ne}}}} = \sqrt{\frac{20 \text{ g/mol}}{4 \text{ g/mol}}} = \sqrt{5} \approx 2.24$$

Thus, helium will effuse approximately 2.24 times faster than neon.

Answer 2

Using Graham's Law to find the rate of diffusion of gas B:

$$\frac{\text{Rate}_A}{\text{Rate}_B} = \sqrt{\frac{\text{Molar Mass}_B}{\text{Molar Mass}_A}}$$

Given that $(\text{Rate}_A = 3.0 \text{ L/min})$, $(\text{Molar Mass}_A = 16 \text{ g/mol})$, and $(\text{Molar Mass}_B = 32 \text{ g/mol})$:

$$\frac{3.0 \text{ L/min}}{\text{Rate}_B} = \sqrt{\frac{32}{16}} = \sqrt{2}$$

This simplifies to:

$$\text{Rate}_B = \frac{3.0 \text{ L/min}}{\sqrt{2}} \approx 2.12 \text{ L/min}$$

Answer 3

To find the ratio of the rates of effusion of ammonia to hydrogen chloride:

$$\frac{\text{Rate}_{\text{NH}_3}}{\text{Rate}_{\text{HCl}}} = \sqrt{\frac{\text{Molar Mass}_{\text{HCl}}}{\text{Molar Mass}_{\text{NH}_3}}}$$

Substituting the values:

$$\frac{\text{Rate}_{\text{NH}_3}}{\text{Rate}_{\text{HCl}}} = \sqrt{\frac{36.5}{17}} \approx \sqrt{2.15} \approx 1.47$$

Thus, ammonia effuses approximately 1.47 times faster than hydrogen chloride.

Answer 4

Using Graham's Law again:

$$\sqrt{\frac{\text{Rate}_1}{\text{Rate}_2}} = \sqrt{\frac{\text{Molar Mass}_2}{\text{Molar Mass}_1}}$$

Let the gas with a molar mass of 28 g/mol be gas 2. We know:

$$\frac{2.5 \text{ L/min}}{\text{Rate}_2} = \sqrt{\frac{28}{44}}$$

Calculating:

$$\text{Rate}_2 = \frac{2.5 \text{ L/min}}{\sqrt{\frac{28}{44}}} \approx \frac{2.5 \text{ L/min}}{0.75} \approx 3.33 \text{ L/min}$$

Answer 5

If $(\text{Rate}_X = 2 \times \text{Rate}_Y)$ and $(\text{Molar Mass}_Y = 18 \text{ g/mol})$, we can set up the equation:

Using Graham's Law:

$$\frac{\text{Rate}_X}{\text{Rate}_Y} = \sqrt{\frac{\text{Molar Mass}_Y}{\text{Molar Mass}_X}}$$

Substituting $(\text{Rate}_X = 2 \times \text{Rate}_Y)$:

$$2 = \sqrt{\frac{18}{\text{Molar Mass}_X}}$$

Squaring both sides:

$$4 = \frac{18}{\text{Molar Mass}_X}$$

Thus,

$$\text{Molar Mass}_X = \frac{18}{4} = 4.5 \text{ g/mol}$$

Conclusion

The Graham's Law worksheet with answers serves as a valuable educational resource for students to practice and reinforce their understanding of gas behavior, specifically concerning diffusion and effusion rates. By working through these problems and reviewing the solutions, students can gain confidence in applying Graham's Law to various scenarios, which is an essential skill in both academic and practical chemistry applications.

Frequently Asked Questions

What is Graham's Law of Effusion?

Graham's Law states that the rate of effusion of a gas is inversely proportional to the square root of its molar mass.

How do you calculate the rate of effusion using Graham's Law?

The rate of effusion (r) can be calculated using the formula $r_1/r_2 = \sqrt{M_2/M_1}$, where M_1 and M_2 are the molar masses of the gases.

What is the significance of molar mass in Graham's Law?

Molar mass is significant in Graham's Law because it determines how fast a gas will effuse; lighter gases effuse faster than heavier gases.

Can Graham's Law be applied to diffusion as well as effusion?

Yes, Graham's Law can be applied to both diffusion and effusion, as both processes are influenced by the molar mass of the gases.

What are some common applications of Graham's Law?

Common applications include predicting the behavior of gases in chemical reactions, determining the rates of gas exchange in biological systems, and calculating the separation of isotopes.

How does temperature affect the rates of effusion according to Graham's Law?

While Graham's Law primarily focuses on molar mass, temperature can affect effusion rates; generally, higher temperatures increase the kinetic energy of gas molecules, leading to faster effusion.

What is the relationship between the rates of two gases with different molar masses?

According to Graham's Law, if one gas has a significantly lower molar mass than another, it will effuse at a rate that is greater than that of the heavier gas.

How can I solve a typical Graham's Law worksheet problem?

First, identify the molar masses of the gases involved, then use the formula $r_1/r_2 = \sqrt{M_2/M_1}$ to find the rate of effusion or diffusion between the two gases.

What units are typically used in Graham's Law calculations?

The units of rate are often in volume per time (e.g., liters per second), and molar mass is in grams per mole (g/mol).

Where can I find additional resources or worksheets on Graham's Law?

Additional resources can be found in chemistry textbooks, educational websites, and online platforms that offer chemistry worksheets and practice problems.

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