

Compute The Relative Speed Of Diffusion Of Ethene (mm = 28.0 G/mol) To Phosgene (mm = 98.9 G/mol):

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Diffusion is a fundamental process in chemistry where molecules spread from regions of higher concentration to regions of lower concentration. Understanding the relative rate at which different gases diffuse is critical in various scientific and industrial applications, including the design of separation processes, understanding atmospheric phenomena, and studying reaction mechanisms. When comparing the diffusion rates of two gases, such as ethene (C₂H₄) and phosgene (COCl₂), it is essential to analyze their molecular properties, particularly their molar masses, and apply principles derived from Graham's Law of Diffusion.

Understanding Graham's Law of Diffusion

Definition of 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. Mathematically, it is expressed as:

$$\frac{r_1}{r_2} = \sqrt{\frac{M_2}{M_1}}$$

Where:

- r_1 and r_2 are the rates of diffusion of gases 1 and 2, respectively.
- M_1 and M_2 are the molar masses of gases 1 and 2, respectively.

Significance of Graham's Law

This law implies that lighter gases diffuse faster than heavier gases. The square root relationship indicates that the rate difference is not linear but follows a square root scale with molar masses.

Molar Masses and Their Role in Diffusion

Molar Mass of Ethene (C₂H₄)

- Atomic masses:
- Carbon (C) = 12.0 g/mol
- Hydrogen (H) = 1.0 g/mol

- Calculation:

$$M_{\text{ethene}} = (2 \times 12.0) + (4 \times 1.0) = 24 + 4 = 28.0 \text{ g/mol}$$

\]

Molar Mass of Phosgene (COCl_2)

- Atomic masses:

- Carbon (C) = 12.0 g/mol

- Oxygen (O) = 16.0 g/mol

- Chlorine (Cl) = 35.5 g/mol

- Calculation:

\[

$$M_{\text{phosgene}} = 12.0 + 16.0 + (2 \times 35.5) = 12 + 16 + 71 = 99.0, \text{ g/mol}$$

\]

Note: The molar mass is given approximately as 98.9 g/mol, which is close enough for calculations.

Calculating the Relative Speed of Diffusion

Applying Graham's Law

Given:

- $(M_1 = 28.0, \text{ g/mol})$ (ethene)

- $(M_2 = 98.9, \text{ g/mol})$ (phosgene)

Using Graham's Law:

\[

$$\frac{r_{\text{ethene}}}{r_{\text{phosgene}}} = \sqrt{\frac{M_{\text{phosgene}}}{M_{\text{ethene}}}}$$

\]

Substituting the known values:

\[

$$\frac{r_{\text{ethene}}}{r_{\text{phosgene}}} = \sqrt{\frac{98.9}{28.0}}$$

\]

Numerical Calculation

1. Compute the ratio:

\[

$$\frac{98.9}{28.0} \approx 3.532$$

\]

2. Take the square root:

\[

$$\sqrt{3.532} \approx 1.878$$

\]

Interpretation of Results

The ratio of their diffusion rates:

$$\frac{r_{\text{ethene}}}{r_{\text{phosgene}}} \approx 1.878 : 1$$

This indicates that ethene diffuses approximately 1.88 times faster than phosgene under identical conditions.

Factors Affecting Gas Diffusion Beyond Molar Mass

Although Graham's Law provides a good approximation, several other factors influence the diffusion rate of gases:

1. Temperature

- Increasing temperature increases molecular velocity, thereby increasing diffusion rates for all gases.
- The relationship remains proportional; higher temperature results in faster diffusion.

2. Pressure

- Diffusion rates are affected by partial pressures; lower ambient pressures generally facilitate faster diffusion.

3. Molecular Size and Shape

- Molecules with irregular shapes or larger sizes may diffuse slower due to increased collision cross-sections.

4. Intermolecular Forces

- Stronger intermolecular attractions can slow down diffusion, especially in gases that can form transient bonds.

Practical Applications of Diffusion Rate Calculations

1. Gas Separation Technologies

- Knowledge of diffusion rates helps optimize processes like gas chromatography and membrane separations.

2. Atmospheric Science

- Understanding how different gases disperse in the atmosphere informs climate modeling and pollution control.

3. Industrial Safety and Design

- Awareness of diffusion speeds of hazardous gases like phosgene is crucial for designing safe handling and containment systems.

Limitations of Graham's Law

While Graham's Law is useful, it assumes:

- Gases behave ideally.
- Diffusion occurs in a uniform medium.
- No interactions between gas molecules beyond elastic collisions.

In real-world applications, deviations can occur due to non-ideal behaviors, especially at high pressures or low temperatures.

Summary and Conclusion

By applying Graham's Law, we have quantitatively determined that ethene diffuses nearly twice as fast as phosgene under identical conditions. The calculation hinges primarily on the molar masses, which underscores the importance of molecular weight in diffusion phenomena. Although the law offers a straightforward approximation, comprehensive analysis of diffusion in practical scenarios must consider additional factors like temperature, pressure, molecular interactions, and molecular geometry.

Understanding these principles not only aids in fundamental scientific comprehension but also informs industrial processes and environmental studies. The ability to predict and control diffusion rates is essential in designing efficient separation techniques, developing safer chemical handling protocols, and modeling environmental dispersion of gases.

References:

- Atkins, P., & de Paula, J. (2010). Physical Chemistry. Oxford University Press.
- Fox, M. (2010). Graham's Law and Gas Diffusion. Journal of Chemical Education.
- Lide, D. R. (Ed.). (2004). CRC Handbook of Chemistry and Physics. CRC Press.

Frequently Asked Questions

How is the relative speed of diffusion of ethene compared to phosgene calculated using Graham's law?

Using Graham's law, the ratio of their diffusion speeds is inversely proportional to the square root of

their molar masses: $v_{\text{ethene}} / v_{\text{phosgene}} = \sqrt{M_{\text{phosgene}}} / \sqrt{M_{\text{ethene}}}$.

What is the formula for calculating the relative speed of diffusion between two gases?

The formula is $v_1 / v_2 = \sqrt{M_2} / \sqrt{M_1}$, where v_1 and v_2 are the speeds, and M_1 and M_2 are the molar masses of the gases.

Given the molar masses of ethene (28.0 g/mol) and phosgene (98.9 g/mol), what is the ratio of their diffusion speeds?

The ratio of ethene's speed to phosgene's speed is approximately $\sqrt{98.9} / \sqrt{28.0} \approx 9.95 / 5.29 \approx 1.88$, meaning ethene diffuses about 1.88 times faster than phosgene.

Why does ethene diffuse faster than phosgene according to kinetic molecular theory?

Because ethene has a lower molar mass than phosgene, molecules of ethene move faster on average, resulting in a higher diffusion rate as per Graham's law.

How does the molar mass influence the rate of diffusion of gases?

According to Graham's law, gases with lower molar masses diffuse faster because their molecules have higher average velocities at a given temperature.

Additional Resources

Diffusion: The Natural Phenomenon and Its Significance in Chemical Processes

Understanding the relative speed at which different gases diffuse is fundamental in fields ranging from industrial chemistry to environmental science. The diffusion of gases is governed by their molecular characteristics, primarily molar mass, which influences how quickly they spread through a medium. This article delves into the comparative diffusion rates of ethene (C_2H_4) and phosgene (COCl_2), providing an in-depth analysis rooted in kinetic molecular theory and Graham's Law. By exploring the principles, calculations, and implications, we aim to present a comprehensive perspective on how molecular mass dictates diffusion velocities.

Introduction to Diffusion and Its Importance

Diffusion is the spontaneous movement of particles from a region of higher concentration to one of lower concentration, driven by the kinetic energy of particles. It is a fundamental process influencing

numerous natural and industrial phenomena, such as:

- The dispersion of pollutants in the atmosphere
- The mixing of gases in chemical reactors
- The process of respiration in biological systems
- The separation and purification of gases in industry

The rate at which different gases diffuse depends on their molecular properties, especially molar mass, temperature, and the nature of the medium through which they diffuse.

Understanding the Molecules: Ethene and Phosgene

Before calculating the diffusion rates, it is essential to understand the molecules in question.

Ethene (C₂H₄)

- Molecular formula: C₂H₄
- Molar mass (M_m): 28.0 g/mol
- Physical state: Gas at room temperature
- Uses: Polymer production (polyethylene), ripening agent

Phosgene (COCl₂)

- Molecular formula: COCl₂
- Molar mass (M_m): 98.9 g/mol
- Physical state: Gas at room temperature, highly toxic
- Uses: Industrial chemical in plastics manufacturing, chemical warfare agent (historically)

The stark difference in molar masses indicates that ethene is significantly lighter than phosgene, which will influence their diffusion rates.

Graham's Law of Diffusion

The primary theoretical tool for comparing the diffusion velocities of gases is Graham's Law, which states:

The rate of diffusion or effusion of a gas is inversely proportional to the square root of its molar mass.

Mathematically, this is expressed as:

\[

$$\frac{r_1}{r_2} = \sqrt{\frac{M_2}{M_1}}$$

Where:

- r_1 and r_2 are the diffusion rates (or velocities) of gases 1 and 2, respectively.
- M_1 and M_2 are the molar masses of gases 1 and 2.

In this context:

- Gas 1: Ethene (C_2H_4)
- Gas 2: Phosgene ($COCl_2$)

Calculating the Relative Diffusion Speeds

Applying Graham's Law, the ratio of ethene's diffusion speed to phosgene's is:

$$\frac{r_{\text{ethene}}}{r_{\text{phosgene}}} = \sqrt{\frac{M_{\text{phosgene}}}{M_{\text{ethene}}}}$$

Substituting the molar masses:

$$\frac{r_{\text{ethene}}}{r_{\text{phosgene}}} = \sqrt{\frac{98.9 \text{ g/mol}}{28.0 \text{ g/mol}}}$$

Calculating the ratio:

$$\frac{r_{\text{ethene}}}{r_{\text{phosgene}}} = \sqrt{3.5321} \approx 1.878$$

Interpretation:

- Ethene diffuses approximately 1.88 times faster than phosgene under identical conditions.

This significant difference indicates that lighter gases diffuse more rapidly than heavier ones, a principle that has practical implications in industrial separation processes, environmental monitoring, and safety protocols.

Implications and Real-World Applications

Understanding the diffusion rates of ethene and phosgene is not merely academic; it has tangible

applications across various sectors.

1. Industrial Gas Separation and Purification

- Graham's Law underpins the design of separation techniques like effusion and diffusion columns.
- Lighter gases like ethene can be separated efficiently from heavier gases such as phosgene by leveraging their differential diffusion velocities.

2. Environmental Monitoring and Pollution Control

- Knowledge of diffusion rates helps in modeling how pollutants disperse in the atmosphere.
- Ethene, being more mobile, can quickly diffuse away from emission sources, whereas phosgene requires careful handling due to its toxicity and slower diffusion.

3. Safety and Handling Protocols

- **Due to the slower diffusion rate of phosgene, accidental releases pose significant risks as it can linger longer in confined environments.**
- **Rapid diffusion of ethene can aid in quick dispersion, but its flammability necessitates caution.**

4. Biological and Medical Fields

- **Gas exchange in lungs involves diffusion governed by similar principles.**
- **Understanding molecular mass effects assists in designing anesthetic gases and respiratory therapies.**

Additional Factors Affecting Diffusion Rates

While molar mass plays a primary role, other factors influence

diffusion:

- **Temperature:** Higher temperatures increase molecular velocities, speeding up diffusion.
- **Pressure:** Lower pressures tend to increase diffusion rates.
- **Medium:** Diffusion through liquids or solids is more complex but still influenced by molecular interactions and size.
- **Molecular shape and polarity:** These can affect how molecules interact with each other and the medium, modifying diffusion behavior.

In practical calculations, standard conditions (e.g., 25°C, 1 atm) are often assumed unless specified.

Summary of Key Findings

 Parameter 	Ethene (C₂H₄) 	Phosgene (COCl₂) 	Diffusion Rate Ratio (Ethene to Phosgene)
 --- 	--- 	--- 	---
 Molar mass (g/mol) 	28.0 	98.9 	—
 Relative speed 	Faster 	Slower 	1.88 times faster for ethene

The calculations clearly demonstrate that ethene's molecular simplicity and lower molar mass enable it to diffuse significantly faster than phosgene. This understanding is crucial in designing processes and safety measures involving these gases.

Conclusion: The Power of Molecular Mass in Diffusion

The comparative analysis of ethene and phosgene underscores the profound influence of molar mass on diffusion velocities. Graham's Law provides a straightforward yet powerful tool to estimate and compare the rates at which gases spread through a medium. Ethene's lighter molecular weight allows it to diffuse almost twice as rapidly as phosgene under identical conditions, a fact with far-reaching implications in industry, safety, and environmental science.

In a broader context, this exploration exemplifies how fundamental chemical principles translate into practical applications, guiding engineers, scientists, and safety professionals in making informed decisions. Whether designing efficient separation units or developing safety protocols, understanding the nuances of gas diffusion rooted in molecular properties is indispensable.

In essence, the molecular mass difference between ethene and phosgene not only shapes their diffusion rates but also influences how we handle, utilize, and monitor these gases in various contexts—highlighting the enduring relevance of kinetic molecular theory in real-world scenarios.

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**Compute The Relative Speed Of Diffusion Of Ethene Mm 28 0
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