

The Vapour Pressure Of Liquid Bromine (Br₂) At 9.03 Degrees Celcius Is 13.332K Pa And Enthalpy Of Vapourisation

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Understanding the properties of liquid bromine, especially its vapour pressure at specific temperatures, is essential for various scientific and industrial applications. At 9.03°C, the vapour pressure of bromine (Br₂) is precisely measured at 13.332 kPa, revealing critical insights into its volatility and phase behavior. Additionally, the enthalpy of vapourisation—the energy required to convert bromine from a liquid to a gaseous state—plays a vital role in thermodynamic calculations and process design. This article delves into the significance of these properties, their measurement, implications, and how they relate to the broader understanding of bromine's physical chemistry.

Introduction to Bromine and Its Physical Properties

Bromine is a halogen element with the chemical symbol Br and atomic number 35. It exists as a reddish-brown liquid at room temperature and is notable for its high reactivity and distinctive properties. Its unique physical characteristics make it a subject of interest in chemistry, environmental science, and industrial manufacturing.

Understanding the vapour pressure of bromine at various temperatures is crucial because it determines the conditions under which bromine transitions from liquid to gas. The vapour pressure impacts storage, handling, and application safety, especially considering bromine's toxicity and corrosiveness.

Vapour Pressure of Bromine at 9.03°C: Significance and Measurement

What Is Vapour Pressure?

Vapour pressure is the pressure exerted by a vapor in equilibrium with its liquid phase at a given temperature. It indicates the tendency of a substance to evaporate; higher vapour pressures denote more volatile substances. For bromine at 9.03°C, the vapour pressure is measured at 13.332 kPa, reflecting its moderate volatility at this temperature.

Importance of Vapour Pressure Data

- Design of Storage Containers: Knowing the vapour pressure helps in selecting appropriate materials and pressure relief systems to prevent accidents.
- Process Control: It aids in controlling processes like distillation or vaporization in industrial settings.
- Environmental Impact: Understanding vapour pressure assists in predicting bromine's behavior in the environment, including its evaporation rates and potential for atmospheric dispersion.

Methods of Measurement

Measuring vapour pressure involves several techniques, including:

- Manometric Methods: Using a manometer to measure pressure directly at equilibrium.
- Dynamic Methods: Monitoring the rate of evaporation or condensation.
- Vapor Pressure Tables and Equations: Employing empirical correlations and equations like the Clausius-Clapeyron equation to estimate vapour pressure at various temperatures.

In the case of bromine, precise measurements at specific temperatures like 9.03°C are often obtained through careful laboratory techniques to ensure safety and accuracy.

Enthalpy of Vapourisation: Definition and Calculation

What Is Enthalpy of Vapourisation?

The enthalpy of vapourisation (ΔH_{vap}) is the amount of energy required to convert one mole of a liquid into vapor at constant temperature and pressure. For bromine, this value indicates how much energy must be supplied to

overcome intermolecular forces and facilitate phase change.

Significance in Thermodynamics

- Energy Balance: It is a critical parameter in thermodynamic calculations involving phase changes.
- Process Optimization: Helps in designing energy-efficient distillation and purification processes.
- Predictive Modelling: Enables the estimation of vapour pressures at different temperatures via the Clausius-Clapeyron equation.

Determining Enthalpy of Vapourisation for Bromine

The enthalpy of vapourisation can be determined experimentally through calorimetry or derived from vapor pressure data using the Clausius-Clapeyron equation:

$$\bullet \ln(P) = -\Delta H_{\text{vap}} / (RT) + C$$

Where:

- P is the vapour pressure,
- R is the universal gas constant,
- T is the temperature in Kelvin,
- C is a constant.

Plotting $\ln(P)$ against $1/T$ yields a straight line whose slope equals $-\Delta H_{\text{vap}} / R$, enabling calculation of the enthalpy of vapourisation.

Note: For bromine, the enthalpy of vapourisation at its boiling point (~58°C) is approximately 30 kJ/mol, but it varies with temperature and needs to be assessed at specific conditions like 9.03°C.

Implications of Vapour Pressure and Enthalpy of Vapourisation for Bromine

Safety and Handling

Given that bromine's vapour pressure at 9.03°C is 13.332 kPa, operators must design storage systems that prevent pressure buildup. Proper ventilation and sealed containers with pressure relief valves are essential to avoid leaks or

explosions.

Industrial Applications

- Chemical Manufacturing: Bromine is used in the synthesis of flame retardants, pharmaceuticals, and dyes. Knowing its vapour pressure assists in designing extraction and purification processes.
- Water Treatment: Bromine-based disinfectants require controlled vaporization; understanding vapour pressure helps optimize dosage and safety protocols.

Environmental Considerations

Bromine's volatility influences its dispersal in the atmosphere, potentially contributing to environmental pollution. Accurate vapour pressure data aid in modeling its environmental fate and designing mitigation strategies.

Factors Influencing Vapour Pressure and Vapourisation Enthalpy

Temperature Dependence

Vapour pressure increases exponentially with temperature, following the Clausius-Clapeyron relation. As temperature rises, bromine's vapour pressure approaches atmospheric levels, increasing its volatility.

Intermolecular Forces

Bromine molecules are held together by Van der Waals forces. The strength of these forces affects the enthalpy of vapourisation; stronger intermolecular attractions require more energy to overcome.

Purity of Bromine

Impurities can alter vapour pressure measurements and enthalpy values, emphasizing the need for high-purity samples in experimental determinations.

Conclusion: The Significance of Accurate Vapour Pressure and Enthalpy Data

The vapour pressure of liquid bromine at 9.03°C being 13.332 kPa, combined with its enthalpy of vapourisation, provides essential insights into its phase behavior and thermodynamic properties. These parameters are critical for ensuring safe handling, optimizing industrial processes, and understanding environmental impacts.

Accurate measurement and understanding of these properties enable scientists and engineers to design safer storage systems, develop efficient manufacturing techniques, and predict bromine's behavior in various conditions. As research advances, continued refinement of vapour pressure and vapourisation enthalpy data will further enhance our ability to utilize bromine effectively while mitigating associated risks.

Key Takeaways:

- Vapour pressure at 9.03°C: 13.332 kPa
- Enthalpy of vapourisation influences the energy required for phase change
- These properties are vital for safety, industrial processes, and environmental management
- Understanding temperature dependence and intermolecular forces aids in accurate modeling

By mastering these fundamental properties, professionals in chemistry, chemical engineering, and environmental science can better harness bromine's unique characteristics for a wide range of applications.

Disclaimer: All values mentioned are subject to experimental variation and should be confirmed with up-to-date literature and safety guidelines.

Frequently Asked Questions

What is the vapour pressure of liquid bromine at 9.03°C?

The vapour pressure of liquid bromine at 9.03°C is 13.332 kPa.

How does temperature affect the vapour pressure of bromine?

As temperature increases, the vapour pressure of bromine increases, indicating more molecules escape into the vapour phase.

What is the significance of the enthalpy of vapourisation for bromine?

The enthalpy of vapourisation represents the amount of energy required to convert one mole of bromine from liquid to vapour at constant temperature and pressure.

How can the vapour pressure data of bromine be used to determine its enthalpy of vapourisation?

Using the Clausius-Clapeyron equation, vapour pressure measurements at different temperatures can be plotted to calculate the enthalpy of vapourisation.

Why is understanding the vapour pressure of bromine important in industrial applications?

Knowing bromine's vapour pressure helps in safe handling, storage, and designing processes involving bromine vapour, as well as in controlling its phase changes.

What role does the enthalpy of vapourisation play in phase equilibrium calculations for bromine?

It helps determine the temperature and pressure conditions at which bromine transitions between liquid and vapour phases, essential for phase equilibrium analysis.

Additional Resources

Vapour Pressure of Liquid Bromine (Br₂) at 9.03°C: An In-Depth Analysis of Its Properties and Enthalpy of Vapourization

Introduction

When exploring the fascinating world of halogen chemistry, liquid bromine (Br₂) stands out due to its unique physical and chemical properties. Among these, vapour pressure plays a critical role in understanding its volatility, handling safety, and industrial applications. At a temperature of 9.03°C, liquid bromine exhibits a vapour pressure of approximately 13.332 kPa, a value that offers vital insights into its phase behavior and thermodynamic characteristics, particularly its enthalpy of vapourization.

This article provides an in-depth examination of the vapour pressure of bromine at this specific temperature, contextualizing its significance in

both scientific and practical contexts. We will also explore the enthalpy of vapourization, which measures the energy required for bromine molecules to transition from the liquid to the gaseous phase. Through a detailed discussion, readers will better appreciate the importance of these properties in chemical processes, safety protocols, and industrial applications.

Understanding Vapour Pressure: The Basics

Vapour pressure is a fundamental concept in physical chemistry, reflecting the pressure exerted by a vapor in equilibrium with its liquid at a given temperature. It is indicative of a substance's volatility: the higher the vapour pressure at a certain temperature, the more readily the substance evaporates.

For bromine, a volatile liquid at room temperature, vapour pressure is particularly relevant. It influences:

- Industrial handling and storage: High vapour pressures necessitate careful containment.
- Safety considerations: Bromine vapour is toxic and corrosive; understanding its vapour pressure helps mitigate health risks.
- Distillation and purification processes: Vapour pressure data guide temperature control during separation.

Vapour Pressure of Bromine at 9.03°C: Significance and Implications

At 9.03°C, bromine's vapour pressure is measured at 13.332 kPa. To contextualize this:

- Comparison with atmospheric pressure: Standard atmospheric pressure at sea level is approximately 101.3 kPa. Bromine's vapour pressure at 9.03°C is significantly lower, indicating that it remains mostly in liquid form under these conditions.
- Volatility considerations: Though bromine is volatile, this vapour pressure suggests that at just above freezing, it does not readily vaporize into the atmosphere unless heated or disturbed.
- Industrial relevance: In processes where bromine is used or stored at temperatures near this point, understanding the vapour pressure helps optimize safety measures—such as ventilation and containment—to prevent accidental inhalation or release.

The Clausius-Clapeyron Equation: Connecting Vapour Pressure and Enthalpy of Vapourization

The relationship between vapour pressure and temperature is described by the

Clausius-Clapeyron equation:

$$\ln P = -\frac{\Delta H_{\text{vap}}}{RT} + C$$

where:

- P is the vapour pressure,
- ΔH_{vap} is the enthalpy of vapourization,
- R is the universal gas constant ($8.314 \text{ J mol}^{-1} \text{ K}^{-1}$),
- T is the temperature in Kelvin,
- C is a constant specific to the substance.

This equation enables scientists to estimate the enthalpy of vapourization (ΔH_{vap}) based on experimental vapour pressure data across different temperatures, or vice versa.

Enthalpy of Vapourization of Bromine: What It Tells Us

Enthalpy of vapourization, also called the heat of vaporization, quantifies the amount of energy required to convert one mole of a substance from the liquid to the vapour phase at constant temperature. For bromine, this value is crucial for several reasons:

- Design of chemical processes: Knowing ΔH_{vap} helps in designing distillation units, reactors, and storage systems.
- Thermodynamic stability: It offers insights into the strength of intermolecular forces within bromine molecules.
- Safety and handling: Helps in understanding the energy involved in vaporization, influencing safety protocols during heating or cooling.

Typical values for bromine's enthalpy of vapourization are around 30 kJ/mol at its boiling point ($\sim 58.8^\circ\text{C}$). However, at 9.03°C , the value might differ slightly due to temperature dependence.

Calculating Enthalpy of Vapourization at 9.03°C

Using the vapour pressure data at 9.03°C , and assuming the vapour pressure at the boiling point (58.8°C) is known, the enthalpy of vapourization can be estimated:

1. Convert temperatures to Kelvin:

$$T_1 = 9.03 + 273.15 = 282.18 \text{ K}$$

\]

$$\begin{aligned} T_2 &= 58.8 + 273.15 = 331.95, \text{ K} \end{aligned}$$

2. Express vapour pressures in consistent units:

$$P_1 = 13.332, \text{ kPa}$$

$$P_2 = 101.3, \text{ kPa} \quad (\text{at boiling point})$$

3. Apply the Clausius-Clapeyron equation in its two-point form:

$$\Delta H_{\text{vap}} = R \times \frac{\ln P_2 - \ln P_1}{(1/T_1) - (1/T_2)}$$

Plugging in the values:

$$\Delta H_{\text{vap}} = 8.314 \times \frac{\ln(101.3) - \ln(13.332)}{(1/282.18) - (1/331.95)}$$

Calculating step-by-step:

$$\begin{aligned} & - (\ln(101.3) \approx 4.620) \\ & - (\ln(13.332) \approx 2.590) \\ & - \text{Difference: } (4.620 - 2.590 = 2.030) \\ & - (1/282.18 \approx 0.003546, \text{ K}^{-1}) \\ & - (1/331.95 \approx 0.003013, \text{ K}^{-1}) \\ & - \text{Difference: } (0.003546 - 0.003013 = 0.000533, \text{ K}^{-1}) \end{aligned}$$

Now,

$$\Delta H_{\text{vap}} = 8.314 \times \frac{2.030}{0.000533} \approx 8.314 \times 3810.3 \approx 31,701, \text{ J mol}^{-1}$$

or approximately 31.7 kJ/mol.

This estimation aligns well with literature values, confirming that the enthalpy of vapourization for bromine at 9.03°C is close to 30–32 kJ/mol.

Practical Implications of Vapour Pressure and Enthalpy of Vapourization

Understanding these thermodynamic parameters informs various practical aspects:

- **Storage and Handling:** Bromine must be stored in sealed, corrosion-resistant containers, especially when heated or in warm environments, since increased temperature raises vapour pressure, risking leaks or vapor buildup.
- **Industrial Processes:** For processes like bromination reactions or purification, temperature control is vital to maintain desired phase states and avoid excess vaporization.
- **Safety Protocols:** Knowledge of vapour pressure at different temperatures helps design ventilation systems and safety measures to prevent inhalation exposure and environmental release.
- **Environmental Impact:** Bromine vapour can contribute to atmospheric chemistry, including ozone depletion. Accurate vapour pressure data aid in modeling its environmental fate.

Conclusion

The vapour pressure of liquid bromine at 9.03°C, approximately 13.332 kPa, offers valuable insights into its volatility and phase stability under near-freezing conditions. Coupled with an enthalpy of vapourization around 30–32 kJ/mol, these properties highlight bromine's moderate volatility and the energy barrier for phase transition.

From an industrial perspective, understanding these thermodynamic parameters is essential for safe handling, efficient process design, and environmental considerations. Whether used in chemical synthesis, water treatment, or other specialized applications, bromine's vapour pressure characteristics at specific temperatures underpin its practical utility and safety protocols.

In sum, the detailed study of bromine's vapour pressure and enthalpy of vapourization not only deepens scientific comprehension but also enhances operational safety and environmental stewardship in its myriad applications.

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