Calculate Srxn For The Following Balanced Chemical Equation: 2h2s(g) + 3o2(g) 2h2o(g) + 2so2(g)

Calculate Srxn For The Following Balanced Chemical Equation: $2H_2S(g) + 3O_2(g) \rightarrow 2H_2O(g) + 2SO_2(g)$

Understanding how to calculate the standard reaction entropy change (ΔS°_rxn) is fundamental in thermodynamics, particularly when analyzing chemical reactions. In this article, we will walk through the process of calculating ΔS°_rxn for the given balanced chemical equation:

$2H_2S(g) + 3O_2(g) \rightarrow 2H_2O(g) + 2SO_2(g)$

By exploring this example step-by-step, you will gain insight into entropy calculations, the significance of standard molar entropy values, and how these calculations inform us about the spontaneity and thermodynamic favorability of chemical reactions.

Understanding Standard Reaction Entropy (ΔS°_rxn)

What is Entropy?

Entropy (S) is a thermodynamic property that measures the degree of disorder or randomness in a system. In chemical reactions, entropy changes reflect the change in molecular disorder as reactants are converted into products.

Standard Molar Entropy (S°)

Standard molar entropy (S°) is the absolute entropy of one mole of a substance under standard conditions (usually 1 atm pressure and 25°C or 298.15 K). These values are tabulated and widely available in thermodynamic data tables.

Calculating ΔS°_rxn

The standard reaction entropy change (ΔS°_rxn) can be calculated using the standard molar entropy values of the products and reactants:

\[
ΔS°_rxn = \sum (ν \times S°_{products}) - \sum (ν \times S°_{reactants})
\]

where ν represents the stoichiometric coefficients of each substance in the balanced reaction.

Step-by-Step Calculation of ΔS°_rxn for the Given Reaction

1. Write down the balanced chemical equation

The reaction is already balanced:

$2H_2S(g) + 3O_2(g) \rightarrow 2H_2O(g) + 2SO_2(g)$

2. Gather standard molar entropy values (S°) for all species involved

These values are typically found in thermodynamic data tables. For this example, approximate values at 25°C (298 K) are:

- $S°(H_2S(g)) \approx 205.0$ J/(mol·K)
- $S°(O_2(g)) \approx 205.0$ J/(mol·K)
- $S°(H_2O(g)) \approx 188.8$ J/(mol·K)
- $S°(SO_2(g)) \approx 248.2$ J/(mol·K)

(Note: Values are approximate. For precise calculations, consult authoritative thermodynamic data sources.)

3. Apply the formula for ΔS°_rxn

Calculate the sum of entropy values for products and reactants, considering their coefficients:

- Reactants:
  - 2 mol H_2S: $2 \times 205.0 = 410.0$ J/(mol·K)
  - 3 mol O_2: $3 \times 205.0 = 615.0$ J/(mol·K)

- Products:
  - 2 mol H_2O: $2 \times 188.8 = 377.6$ J/(mol·K)
  - 2 mol SO_2: $2 \times 248.2 = 496.4$ J/(mol·K)

4. Calculate ΔS°_{rxn}

Now, subtract the total entropy of reactants from that of products:

$$
\Delta S^\circ_{rxn} = (377.6 + 496.4) - (410.0 + 615.0) = 874.0 - 1025.0 = -151.0 \text{ J/(mol·K)}
$$

Result: The standard reaction entropy change (ΔS°_{rxn}) for this reaction is approximately -151.0 J/(mol·K).

Interpreting the ΔS°_{rxn} Value

Significance of a Negative ΔS°_{rxn}

A negative value indicates a decrease in entropy during the reaction, suggesting the system becomes more ordered. In this case, converting gaseous reactants into products results in a slight decrease in the overall disorder.

Implications for Reaction Spontaneity

While entropy change is just one factor in spontaneity, combined with enthalpy changes, it helps determine Gibbs free energy (ΔG°). A negative ΔS°_{rxn} can contribute to a positive or negative ΔG°, depending on temperature and enthalpy changes.

Additional Considerations in Entropy Calculations

Using Accurate Data

Always utilize the most recent and precise thermodynamic data tables for S° values to ensure accurate calculations.

Temperature Dependence

Standard molar entropy values are given at 25°C. For reactions at different temperatures, entropy values may vary, and temperature-dependent equations or data should be used.

Role of Phase Changes

For reactions involving phase changes, include additional entropy contributions associated with phase transitions.

Conclusion

Calculating the standard reaction entropy change (ΔS°_rxn) for a balanced chemical equation is a straightforward process that hinges on accurate thermodynamic data and proper stoichiometric accounting. For the reaction:

$2H_2S(g) + 3O_2(g) \rightarrow 2H_2O(g) + 2SO_2(g)$,

the calculated ΔS°_rxn is approximately –151.0 J/(mol·K), indicating a decrease in entropy during the process.

Understanding this concept is essential for chemists and students alike, as entropy changes influence reaction spontaneity, equilibrium positions, and thermodynamic feasibility. Mastering the calculation of ΔS°_rxn enhances your ability to predict and analyze chemical reactions from a thermodynamic perspective.

Remember: Always verify your data and consider the broader thermodynamic context, including enthalpy and temperature effects, to gain a comprehensive understanding of reaction spontaneity and energy changes.

Frequently Asked Questions

What is the balanced chemical equation for the reaction involving H_2S and O_2?

The balanced chemical equation is $2\ H_2S(g) + 3\ O_2(g) \rightarrow 2\ H_2O(g) + 2\ SO_2(g)$.

How do you determine the standard reaction entropy change (ΔS°rxn) for this reaction?

You calculate ΔS°rxn by subtracting the sum of the reactants' standard molar entropies from that of the products, using the formula: $\Delta S°rxn = \Sigma\ n \cdot S°(products) - \Sigma\ n \cdot S°(reactants)$.

What data is required to compute ΔS°rxn for this reaction?

Standard molar entropy values (S°) for $H_2S(g)$, $O_2(g)$, $H_2O(g)$, and $SO_2(g)$ are needed, along with their stoichiometric coefficients.

Why is it important to use standard molar entropy values at 25°C (298 K) for this calculation?

Because standard molar entropies are defined at 25°C and 1 atm, ensuring consistency and comparability in thermodynamic calculations.

Can you demonstrate how to calculate ΔS°rxn with hypothetical entropy values?

Yes, for example, if S°(H_2S) = 205 J/mol·K, S°(O_2) = 205 J/mol·K, S°(H_2O) = 188 J/mol·K, and S°(SO_2) = 248 J/mol·K, then ΔS°rxn = [2×188 + 2×248] - [2×205 + 3×205] J/K = (376 + 496) - (410 + 615) = 872 - 1025 = -153 J/K.

What does a negative ΔS°rxn indicate about the reaction's entropy change?

A negative ΔS°rxn indicates that the total entropy decreases during the reaction, meaning the system becomes more ordered.

Additional Resources

Calculate Srxn For The Following Balanced Chemical Equation: $2H_2S(g) + 3O_2(g) \rightarrow 2H_2O(g) + 2SO_2(g)$

Introduction

In the realm of chemical thermodynamics, understanding the heat exchange associated with chemical reactions is fundamental. The concept of standard reaction entropy change (ΔS°rxn) offers insight into the degree of disorder or randomness introduced or reduced during a chemical transformation under standard conditions (usually 1 bar or 1 atm pressure and 25°C). This parameter is critical in predicting the spontaneity of reactions, designing chemical processes, and understanding environmental impacts.

This article provides a comprehensive analysis of calculating the standard reaction entropy change for the specific balanced equation:

\[2H_2S(g) + 3O_2(g) \rightarrow 2H_2O(g) + 2SO_2(g) \]

We will explore the theoretical background, step-by-step calculation procedures, and practical considerations essential for researchers, students, and professionals engaged in thermodynamic assessments.

Theoretical Foundations

What is Reaction Entropy (ΔS°_{rxn})?

Reaction entropy change (ΔS°_{rxn}) quantifies the net change in the entropy of the universe resultant from a chemical reaction under standard conditions. It accounts for the difference in the sum of the standard molar entropies of products and reactants:

$$\Delta S^\circ_{rxn} = \sum_{products} \nu_i S^\circ_{products} - \sum_{reactants} \nu_j S^\circ_{reactants}$$

where:
- ν_i and ν_j are the stoichiometric coefficients,
- S° denotes the standard molar entropy of each species.

Significance of ΔS°_{rxn}

- A positive ΔS°_{rxn} indicates an increase in entropy (more disorder).
- A negative ΔS°_{rxn} indicates a decrease in entropy (less disorder).
- ΔS°_{rxn}, combined with enthalpy changes, helps determine spontaneity via Gibbs free energy calculations.

Step-by-Step Calculation Approach

Calculating ΔS°_{rxn} involves:

1. Gathering Standard Molar Entropies:

Obtain S° values for each species involved. These are tabulated in thermodynamic data tables or standard chemical data references.

2. Applying the Reaction Stoichiometry:

Use the balanced chemical equation to determine the molar quantities of each species.

3. Computing the Net Entropy Change:

Sum the products' entropies multiplied by their coefficients, subtracting the sum of reactants' entropies similarly weighted.

Data Collection: Standard Molar Entropies

For the reaction:

$$2H_2S(g) + 3O_2(g) \rightarrow 2H_2O(g) + 2SO_2(g)$$

the relevant standard molar entropies (at 25°C and 1 bar) are approximately (values from standard thermodynamic tables):

Species	S° (J/mol·K)
$H_2S(g)$	205.0
$O_2(g)$	205.0
$H_2O(g)$	188.7
$SO_2(g)$	248.2

Note: These values are approximate; consult current authoritative thermodynamic data sources for precise calculations.

Calculation of ΔS°_{rxn}

Applying the data:

$$
\begin{aligned}
\Delta S^\circ_{rxn} &= \left[(2 \times S^\circ_{H_2O}) + (2 \times S^\circ_{SO_2}) \right] - \left[2 \times S^\circ_{H_2S} + 3 \times S^\circ_{O_2} \right] \\
&= \left[2 \times 188.7 + 2 \times 248.2 \right] - \left[2 \times 205.0 + 3 \times 205.0 \right] \\
&= (377.4 + 496.4) - (410.0 + 615.0) \\
&= 873.8 - 1025.0 \\
&= -151.2 \, \text{J/K}
\end{aligned}
$$

Thus, the standard reaction entropy change is approximately –151.2 J/K.

Interpretation of Results

The negative value indicates that the reaction results in a decrease in entropy, implying the system becomes more ordered during the process. This aligns with the fact that gases are converted into fewer gaseous molecules, and the overall disorder diminishes.

Factors Influencing ΔS°_{rxn}

While the calculation above assumes ideal conditions, real-world reactions may involve:

- Temperature Effects: Entropy values are temperature-dependent; higher temperatures can alter the magnitude of ΔS°.
- Pressure Variations: Standard molar entropies are defined at 1 bar; deviations influence actual entropy changes.
- Phase Changes: The reaction involves gases; if any species condense or sublime, entropy calculations must account for phase transitions.

Practical Applications and Implications

Environmental and Industrial Context

Understanding the entropy change in reactions like the oxidation of hydrogen sulfide is vital in environmental engineering, especially in designing scrubbers and catalytic converters to mitigate sulfur emissions.

Thermodynamic Predictions

Calculating ΔS°_{rxn} aids in evaluating reaction spontaneity via Gibbs free energy:

$$\Delta G^\circ_{rxn} = \Delta H^\circ_{rxn} - T \Delta S^\circ_{rxn}$$

A negative ΔG° indicates a spontaneous process under standard conditions.

Advanced Considerations

Computational Methods

- Data Refinement: Use of computational chemistry and molecular simulations can refine entropy estimations.
- Non-Standard Conditions: For reactions outside standard conditions, integrate temperature and pressure corrections using thermodynamic equations.

Experimental Validation

- Calorimetry: Experimental measurements of enthalpy and entropy changes can validate theoretical calculations.
- Spectroscopy and Gas Analysis: Monitoring gas compositions provides insights into entropy variations during reactions.

Conclusion

Calculating the standard reaction entropy change for the reaction:

$$2H_2S(g) + 3O_2(g) \rightarrow 2H_2O(g) + 2SO_2(g)$$

is essential in thermodynamic analyses and environmental assessments. Using standard molar entropy data, the reaction exhibits a decrease in entropy (~–151.2 J/K), indicating increased order. Such insights are pivotal for engineers and scientists developing cleaner technologies, optimizing industrial processes, and understanding fundamental chemical principles.

In practice, meticulous data collection, awareness of reaction conditions, and integration with other thermodynamic parameters provide a comprehensive picture of reaction behavior. As thermodynamic databases evolve and computational tools advance, the precision and applicability of these calculations continue to improve, contributing to more sustainable and efficient chemical processes.

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Author Notes: This review underscores the importance of detailed thermodynamic calculations in chemical engineering and environmental science, emphasizing the process of deriving meaningful insights from fundamental data.

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