# So2 (5.00 G) And Co2 (5.00 G) Were Placed In A 750.0 Ml Container At 50.0 C. The Total Pressure In The

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Introduction

Understanding the behavior of gases under different conditions is fundamental in chemistry, especially when dealing with gas mixtures. In this scenario, sulfur dioxide ($SO_2$) and carbon dioxide ($CO_2$) are placed together in a fixed volume container at a specific temperature. Determining the total pressure involves applying principles from the ideal gas law and understanding the properties of each gas. This article provides a comprehensive analysis of the problem, including calculations, explanations of the concepts involved, and implications for real-world applications.

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Basic Concepts and Theoretical Background

The Ideal Gas Law

The ideal gas law is the cornerstone of gas behavior analysis:

$$PV = nRT$$

Where:
- $P$ = pressure (atm, Pa, or kPa)
- $V$ = volume (L, $m^3$)
- $n$ = number of moles (mol)
- $R$ = ideal gas constant ($0.08206 \, \mathrm{L\,atm\,mol^{-1}\,K^{-1}}$)
- $T$ = temperature (Kelvin, K)

Dalton’s Law of Partial Pressures

The total pressure exerted by a mixture of gases is the sum of the partial pressures of individual gases:

$$P_{total} = P_{SO_2} + P_{CO_2}$$

Each partial pressure can be calculated using the ideal gas law, considering the moles of each gas.

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## Step-by-Step Solution: Calculating Total Pressure

### 1. Convert Masses to Moles

The first step involves converting the given masses of $SO_2$ and $CO_2$ to moles.

- Molecular weights:
- $SO_2$: $32.06 \, (\mathrm{S}) + 2 \times 16.00 \, (\mathrm{O}) = 64.06 \, \mathrm{g/mol}$
- $CO_2$: $12.01 \, (\mathrm{C}) + 2 \times 16.00 \, (\mathrm{O}) = 44.01 \, \mathrm{g/mol}$

- Moles of $SO_2$:

$$
n_{SO_2} = \frac{5.00\, \mathrm{g}}{64.06\, \mathrm{g/mol}} \approx 0.0781\, \mathrm{mol}
$$

- Moles of $CO_2$:

$$
n_{CO_2} = \frac{5.00\, \mathrm{g}}{44.01\, \mathrm{g/mol}} \approx 0.1136\, \mathrm{mol}
$$

### 2. Convert Volume to Liters

Given volume:

$$
V = 750.0\, \mathrm{mL} = 0.750\, \mathrm{L}
$$

### 3. Convert Temperature to Kelvin

Temperature:

$$
T = 50.0^\circ C = 50.0 + 273.15 = 323.15\, \mathrm{K}
$$

### 4. Calculate Partial Pressures

Using the ideal gas law for each gas:

$$
P = \frac{nRT}{V}
$$

- For $SO_2$:

$$
P_{SO_2} = \frac{0.0781\, \mathrm{mol} \times 0.08206\, \mathrm{L\,atm\,mol^{-1}\,K^{-1}} \times 323.15\, \mathrm{K}}{0.750\, \mathrm{L}} \approx 2.75\, \mathrm{atm}
$$

- For $CO_2$:

$$
P_{CO_2} = \frac{0.1136\, \mathrm{mol} \times 0.08206\, \mathrm{L\,atm\,mol^{-1}\,K^{-1}} \times 323.15\, \mathrm{K}}{0.750\, \mathrm{L}} \approx 3.99\, \mathrm{atm}
$$

5. Calculate Total Pressure

Applying Dalton's Law:

$$
P_{total} = P_{SO_2} + P_{CO_2} \approx 2.75\, \mathrm{atm} + 3.99\, \mathrm{atm} = 6.74\, \mathrm{atm}
$$

Summary of Results

| Parameter | Value |
|---|---|
| Moles of $SO_2$ | 0.0781 mol |
| Moles of $CO_2$ | 0.1136 mol |
| Partial pressure of $SO_2$ | 2.75 atm |
| Partial pressure of $CO_2$ | 3.99 atm |
| Total pressure | 6.74 atm |

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Real-World Applications of Gas Law Calculations

Understanding how gases behave in confined spaces has numerous practical applications:

- Industrial Chemical Processes: Precise control of gas mixtures is critical in manufacturing, such as in the production of sulfuric acid or carbonated beverages.
- Environmental Monitoring: Estimating pollutant gases' pressures and concentrations in the atmosphere.
- Engineering Design: Designing pressurized containers, reactors, and pipelines ensuring safety and efficiency.
- Laboratory Experiments: Accurate calculations enable scientists to replicate or predict experimental outcomes.

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Factors Affecting Gas Behavior

While the ideal gas law provides a good approximation, real gases deviate under certain conditions:

- High Pressure: Gases become less ideal as molecules interact more.
- Low Temperature: Molecular interactions dominate, affecting pressure and volume.
- Molecular Size and Interactions: Larger molecules or those with significant intermolecular forces deviate more from ideality.

In our scenario, the temperature and pressure are moderate, so the ideal gas law offers an acceptable approximation.

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Limitations and Assumptions in the Calculation

- Ideal Gas Assumption: Assumes gases behave ideally; real gases may differ slightly.
- No Gas Interactions: Assumes gases do not interact or react chemically.
- Constant Volume and Temperature: Assumes the system remains at constant volume and temperature throughout.

Understanding these limitations helps in assessing the accuracy and applicability of the calculations.

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Additional Considerations for Gas Mixtures

Gas Solubility and Miscibility

- Solubility: $CO_2$ is more soluble in liquids than $SO_2$, which can influence behavior in different environments.
- Miscibility: Both gases are miscible, meaning they can mix uniformly without separation.

Effect of Gas Ratios

- The ratio of gases can influence pressure, reactivity, and other physical properties.
- Adjusting initial masses alters the partial pressures and overall system behavior.

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Practical Example: Laboratory Scenario

Suppose a chemist wants to predict the pressure exerted by a mixture of $SO_2$ and $CO_2$ in a sealed container at a given temperature. The calculations above provide the necessary data to:

- Predict system behavior.
- Ensure safety protocols are met (e.g., pressure limits).
- Design experiments or industrial processes involving these gases.

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Safety Considerations

- Toxicity of $SO_2$: Sulfur dioxide is toxic; proper handling and ventilation are essential.
- Pressure Management: Excess pressure can cause container failure; calculations assist in designing safe systems.
- Temperature Control: Elevated temperatures can increase pressure; systems should be designed accordingly.

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Conclusion

The detailed analysis of $SO_2$ and $CO_2$ gases in a fixed-volume container at 50°C demonstrates the application of fundamental principles in chemistry and physics. Calculating partial and total pressures using the ideal gas law and Dalton's law elucidates how gas quantities translate into measurable pressures. These principles are vital across various fields, from industrial manufacturing to environmental science, emphasizing the importance of understanding gas behaviors for safety, efficiency, and innovation.

In this specific case, the total pressure exerted by the mixture is approximately 6.74 atm, considering the given masses, temperature, and volume. This comprehensive approach ensures accurate predictions and informed decision-making in practical applications involving gas mixtures.

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References

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Note: All calculations are approximate and assume ideal behavior for simplicity.

# Frequently Asked Questions

## What is the total pressure inside the container when $SO_2$ and $CO_2$ gases are placed together at 50.0°C?

The total pressure can be calculated using Dalton's Law by adding the partial pressures of $SO_2$ and $CO_2$, considering their moles and the temperature, resulting in approximately 4.78 atm.

## How do you determine the partial pressure of each gas in the container?

The partial pressure of each gas is found using the ideal gas law: $P = (nRT)/V$, where n is the number of moles, R is the gas constant, T is temperature in Kelvin, and V is volume. Calculate n for each gas first, then find their individual pressures.

## What is the molar amount of $SO_2$ and $CO_2$ in the container?

Given the masses (5.00 g each) and molar masses ($SO_2$ ≈ 64.07 g/mol, $CO_2$ ≈ 44.01 g/mol), the moles are approximately 0.0781 mol for $SO_2$ and 0.1136 mol for $CO_2$.

## How does temperature affect the pressure of gases in the container?

According to the ideal gas law, increasing temperature increases the pressure if volume and moles remain constant, as $P \propto T$ (in Kelvin).

## What assumptions are made when calculating the total pressure of gases in this scenario?

Assumptions include that gases behave ideally, they do not react with each other, and the container is rigid and at constant temperature, allowing the use of Dalton's Law and the ideal gas law.

## Would the pressure change if the container volume was increased? How?

Yes, increasing the volume would decrease the total pressure, as per Boyle's Law ($P \propto 1/V$), assuming temperature and moles of gas remain constant.

# Additional Resources

Understanding the Behavior of $SO_2$ and $CO_2$ Mixtures in a 750.0 mL Container at 50.0°C: A Comprehensive Analysis

When examining gas mixtures, such as sulfur dioxide ($SO_2$) and carbon dioxide ($CO_2$), placed in a confined environment like a 750.0 mL container at a specified temperature, several fundamental principles of chemistry and physics come into play. This detailed exploration aims to dissect the scenario where 5.00 grams of $SO_2$ and 5.00 grams of $CO_2$ are introduced into a container at 50.0°C, and the resulting total pressure is determined. We will approach this systematically, covering the molecular properties, calculations based on ideal gas law assumptions, real-world considerations, and implications of the findings.

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# Introduction to the System

The scenario involves two gases: sulfur dioxide ($SO_2$) and carbon dioxide ($CO_2$). Both are diatomic or polyatomic molecules with distinct molar masses and physical properties. When these gases are confined in a closed container at a given temperature, their behavior is governed primarily by the ideal gas law, provided the conditions do not deviate significantly from ideality.

Key parameters:
- Mass of $SO_2$: 5.00 grams
- Mass of $CO_2$: 5.00 grams
- Volume of container: 750.0 mL (which is 0.7500 L)
- Temperature: 50.0°C (which converts to Kelvin as T = 50.0 + 273.15 = 323.15 K)

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# Physical and Chemical Properties of $SO_2$ and $CO_2$

## Molecular Characteristics

- Sulfur Dioxide ($SO_2$):
- Molar Mass: approximately 64.07 g/mol
- Physical State: gases at room temperature and above
- Colorless to pale yellow, pungent odor
- Soluble in water, forming sulfurous acid

- Carbon Dioxide ($CO_2$):
- Molar Mass: approximately 44.01 g/mol

- Physical State: gases at room temperature
- Colorless, odorless, non-flammable
- Commonly used in carbonated beverages and as a refrigerant

### Implications for Behavior in a Gas Mixture

- Both gases behave ideally under typical laboratory conditions, especially at moderate pressures and temperatures.
- The difference in molar mass affects their partial pressures and diffusion rates.
- $CO_2$, being lighter per mole but with a lower molar mass, will contribute differently to the total pressure than $SO_2$.

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## Calculating the Number of Moles of Each Gas

The first step towards understanding the pressure involves calculating the moles of each gas present.

### For $SO_2$:

$$
n_{SO_2} = \frac{\text{mass}}{\text{molar mass}} = \frac{5.00\, \text{g}}{64.07\, \text{g/mol}} \approx 0.07807\, \text{mol}
$$

### For $CO_2$:

$$
n_{CO_2} = \frac{\text{mass}}{\text{molar mass}} = \frac{5.00\, \text{g}}{44.01\, \text{g/mol}} \approx 0.11363\, \text{mol}
$$

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## Applying the Ideal Gas Law

The ideal gas law relates pressure (P), volume (V), number of moles (n), and temperature (T):

$$
PV = nRT
$$

Where:
- $R$ = ideal gas constant = 0.082057 L·atm/(mol·K)

Using this, the partial pressures of each gas can be calculated individually, assuming ideal behavior, and then summed to find the total pressure.

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# Calculating Partial Pressures

## Partial pressure of $SO_2$:

$$
P_{SO_2} = \frac{n_{SO_2}RT}{V} = \frac{0.07807 \times 0.082057 \times 323.15}{0.7500}
$$

Calculating numerator:

$$
0.07807 \times 0.082057 \times 323.15 \approx 2.075\, \text{L·atm}
$$

Dividing by volume:

$$
P_{SO_2} \approx \frac{2.075}{0.7500} \approx 2.767\, \text{atm}
$$

---

## Partial pressure of $CO_2$:

$$
P_{CO_2} = \frac{n_{CO_2}RT}{V} = \frac{0.11363 \times 0.082057 \times 323.15}{0.7500}
$$

Calculating numerator:

$$
0.11363 \times 0.082057 \times 323.15 \approx 3.035\, \text{L·atm}
$$

Dividing by volume:

$$
P_{CO_2} \approx \frac{3.035}{0.7500} \approx 4.047\, \text{atm}
$$

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## Determining Total Pressure

Since the gases are confined in the same container and behave ideally, their partial pressures add up to give the total pressure:

$$
P_{total} = P_{SO_2} + P_{CO_2} \approx 2.767\, \text{atm} + 4.047\, \text{atm} = 6.814\, \text{atm}
$$

Therefore, the total pressure in the container at 50.0°C is approximately 6.81 atm.

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## Real-World Considerations and Deviations from Ideal Behavior

While the calculations above assume ideal gas behavior, real gases exhibit deviations under certain conditions. Key factors include:

- High Pressure: At pressures significantly above 1 atm, gas molecules are closer, and intermolecular forces become appreciable, causing deviations.
- Low Temperature: Near condensation points, gases may liquefy, invalidating the ideal gas law.
- Molecular Interactions: $SO_2$ has polar characteristics, leading to stronger intermolecular attractions compared to $CO_2$.

Given the pressure (~6.8 atm) and temperature (50°C), the gases are likely still well within the ideal regime, but minor deviations could be considered using real gas equations like van der Waals' equation. However, for most practical purposes, the ideal gas law provides a sufficiently accurate estimate.

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## Additional Aspects to Consider

### Partial Pressures and Gas Behavior

- The partial pressure of each gas reflects its mole fraction relative to the total moles:
- Mole fraction of $SO_2$:
\[

$$
\chi_{SO_2} = \frac{0.07807}{0.07807 + 0.11363} \approx 0.407
$$

- Mole fraction of $CO_2$:

$$
\chi_{CO_2} = 1 - 0.407 = 0.593
$$

- These fractions confirm that $CO_2$ exerts a higher partial pressure due to its greater mole count.

## Impact of Temperature on Gas Behavior

- Increasing temperature would proportionally increase the total pressure, as per Gay-Lussac's law.
- The kinetic energy of molecules increases with temperature, influencing reaction rates if any chemical reactions are considered.

## Solubility and Interaction with Container Walls

- Although not addressed directly in ideal calculations, gases like $SO_2$ are highly soluble in water, which could influence pressure if moisture is present.
- $CO_2$'s solubility also depends on temperature and pressure, potentially reducing the amount of gas in the vapor phase over time.

## Implications in Industrial and Environmental Contexts

- Understanding the pressure of such gas mixtures is critical in designing chemical reactors, storage tanks, and environmental assessments.
- For example, in pollution control, knowing the pressure exerted by sulfur dioxide can influence scrubber design and safety protocols.

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# Summary and Key Takeaways

- The mixture of 5.00 g $SO_2$ and 5.00 g $CO_2$ in a 750.0 mL container at 50.0°C results in an approximate total pressure of 6.81 atm assuming ideal gas behavior.
- Moles of gases are calculated based on their molar masses, and the partial pressures correspond proportionally to their mole fractions.
- Real gases may deviate slightly from these values, especially under higher pressure or lower temperature conditions.
- Understanding these principles is essential in applications ranging from industrial processing to environmental science.

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## Final Remarks

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This comprehensive analysis demonstrates how fundamental principles of
chemistry elucidate the behavior of gas mixtures under specified conditions.
The calculations reinforce the importance of molar quantities, temperature,
and volume in determining pressure, and highlight the utility of the ideal
gas law as a first approximation. For more precise modeling, especially in
high-pressure scenarios or near phase change conditions, more complex
equations of state and experimental data should be employed.

By integrating molecular properties, thermodynamic equations, and practical
considerations, we gain a holistic understanding of gas behavior that is
vital for scientific, industrial, and
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