

The Heat Of Fusion Of Butane Is 80.3 J/g. How Much Heat Is Needed To Melt 25.0 G Of Butane?

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Understanding the concepts of heat transfer and phase changes is fundamental in chemistry and physics. The question, "The heat of fusion of butane is 80.3 J/g. How much heat is needed to melt 25.0 g of butane?" provides a practical example to explore these concepts. In this article, we'll delve into the details of the heat of fusion, how to calculate the required heat, and the significance of this process.

What Is The Heat Of Fusion?

Definition

The heat of fusion, also known as enthalpy of fusion, is the amount of energy required to change a substance from solid to liquid at its melting point without changing its temperature. It is expressed in joules per gram (J/g). This value indicates how much energy must be supplied to overcome the forces holding the solid particles together.

Importance in Phase Changes

Understanding the heat of fusion is essential in many fields, including:

- Cryogenics
- Material science
- Thermal engineering
- Chemistry reactions involving melting processes

Specifics of Butane's Heat Of Fusion

Butane Overview

Butane (C_4H_{10}) is a hydrocarbon that exists as a gas at room temperature but can be compressed into a liquid for storage and transport. It has a melting point at approximately $-138^{\circ}C$, but in the context of the heat of fusion, the focus is on its phase change from solid to liquid.

Heat Of Fusion Value

The heat of fusion of butane is given as 80.3 J/g . This means that to melt 1 gram of solid butane at its melting point, 80.3 joules of energy is required.

Calculating The Heat Needed To Melt Butane

Given Data

- Heat of fusion of butane: 80.3 J/g
- Mass of butane: 25.0 g

Calculation Approach

The calculation involves a simple multiplication:

$$\text{Heat Needed} = \text{Mass} \times \text{Heat of Fusion}$$

Where:

- Mass = 25.0 g
- Heat of Fusion = 80.3 J/g

Step-by-Step Calculation

1. Multiply the mass of butane by its heat of fusion:

$$25.0 \text{ g} \times 80.3 \text{ J/g} = ?$$

2. Perform the multiplication:

$$25.0 \times 80.3 = 2007.5 \text{ J}$$

Answer:

The amount of heat needed to melt 25.0 grams of butane is approximately 2007.5 Joules.

Understanding The Significance of The Calculation

Practical Applications

Knowing how much energy is required to melt a specific amount of butane has several practical implications:

- Designing cooling and heating systems
- Storage and transportation safety measures
- Industrial processes involving hydrocarbon phase changes
- Prediction of energy consumption in process engineering

Thermodynamics Context

This calculation exemplifies the principles of thermodynamics, specifically:

- Energy transfer during phase changes
- Conservation of energy
- The relationship between mass, energy, and phase change properties

Additional Factors To Consider

Temperature Considerations

While the heat of fusion provides the energy needed at the melting point, in real-world situations, temperature differences may influence the actual energy required.

State of Butane

The calculation assumes the butane is initially in solid form at its melting point. If the butane is in a different state or temperature, additional energy calculations may be necessary.

Safety Precautions

Handling butane and other hydrocarbons requires caution due to flammability and potential hazards associated with phase changes involving volatile substances.

Summary of Key Points

- The heat of fusion for butane is 80.3 J/g.
- To melt 25.0 g of solid butane, approximately 2007.5 Joules of energy are needed.
- The calculation involves multiplying the mass by the heat of fusion.
- Understanding phase change energies is crucial in various scientific and industrial applications.

Conclusion

Understanding how much heat is required to melt a given mass of a substance like butane is fundamental in thermodynamics and practical engineering. The straightforward calculation—multiplying the mass by the heat of fusion—provides essential insights into energy requirements for phase transitions. Whether in laboratory settings or industrial applications, these calculations help ensure safety, efficiency, and effective process control. Remember, always consider the specific conditions and safety guidelines when working with volatile substances like butane.

References

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Frequently Asked Questions

What is the heat of fusion of butane?

The heat of fusion of butane is 80.3 J/g.

How much heat is required to melt 25.0 g of butane?

The heat needed is 2,007.5 Joules.

How do you calculate the heat required to melt a given mass of butane?

Multiply the mass of butane by its heat of fusion: $Q = \text{mass} \times \text{heat of fusion}$.

What is the formula to find the heat needed to melt butane?

$Q = m \times \Delta H_{\text{fusion}}$, where Q is heat, m is mass, and ΔH_{fusion} is the heat of fusion per gram.

If you have 25.0 g of butane, how much energy is needed to convert it from solid to liquid?

Approximately 2,007.5 Joules of energy are needed.

Can the heat of fusion value be used for other substances?

No, the heat of fusion is specific to each substance; for butane, it is 80.3 J/g.

Why is understanding the heat of fusion important in thermodynamics?

It helps in calculating energy requirements during phase changes, essential for energy management and process design.

What units should be used when calculating heat of fusion in problems like this?

Use grams for mass and Joules per gram for heat of fusion to ensure consistent units in calculations.

Additional Resources

The Heat Of Fusion Of Butane Is 80.3 J/g. How Much Heat Is Needed To Melt 25.0 G Of Butane?

Understanding the thermodynamics of phase changes is fundamental in both scientific and practical contexts, from industrial processes to everyday applications. When examining substances such as butane, a common hydrocarbon used as fuel, knowing the heat required for phase transitions—specifically melting or fusion—is crucial for efficient energy management and safety considerations. The question posed—"How much heat is needed to melt 25.0 g of butane?"—serves as an excellent example to explore the principles of heat of fusion, the calculation methodology involved, and the broader implications of such thermal properties.

Fundamentals of Heat of Fusion

Defining Heat of Fusion

The heat of fusion (also known as enthalpy of fusion) is the amount of energy required to convert a substance from its solid phase into its liquid phase at its melting point, without changing its temperature. It is expressed in units of energy per unit mass, commonly Joules per gram (J/g). For butane, this value is given as 80.3 J/g.

This value signifies that to melt 1 gram of solid butane at its melting point, 80.3 Joules of heat must be supplied. Conversely, when solid butane absorbs this energy, it undergoes a phase change from solid to liquid without a temperature change, until all the solid has melted.

Physical Significance and Applications

Understanding the heat of fusion is essential for:

- Designing thermal systems that involve phase changes, such as refrigeration or fuel storage.
- Estimating energy requirements in processes where butane is stored or transported in solid form.
- Safety protocols related to temperature management, since incomplete melting could affect the behavior of butane under various conditions.
- Chemical engineering where phase transitions affect reaction conditions or separation processes.

Understanding the Calculation: How Much Heat Is Needed?

The core calculation involves straightforward multiplication, underpinned by the principle that the total heat (Q) required to melt a given mass (m) of a substance is:

$$Q = \text{heat of fusion} \times \text{mass}$$

Given the data:

- Heat of fusion of butane, $\Delta H_{\text{fusion}} = 80.3 \text{ J/g}$
- Mass of butane, $m = 25.0 \text{ g}$

The calculation proceeds as follows:

$$Q = 80.3 \text{ J/g} \times 25.0 \text{ g}$$

$$Q = 2007.5 \text{ J}$$

Therefore, approximately 2007.5 Joules of heat energy are needed to melt 25.0 grams of solid butane at its melting point.

Detailed Breakdown and Implications of the Calculation

Step-by-Step Calculation Explanation

1. Identify the given data:

- Heat of fusion (ΔH_{fusion}) = 80.3 J/g
- Mass (m) = 25.0 g

2. Apply the formula:

- $Q = \Delta H_{\text{fusion}} \times m$

3. Perform the multiplication:

- $80.3 \times 25.0 = 2007.5$

4. Result interpretation:

- The result indicates the energy required for this specific mass of butane to undergo the phase change from solid to liquid at the melting point.

Contextual Understanding of the Result

- Energy magnitude: 2007.5 Joules is comparable to the energy released or absorbed by a small household appliance over a short period. For comparison, boiling a liter of water (which requires about 4.18 kJ per 1°C) would take roughly 0.48 seconds at 100°C with an ideal heater delivering 2000 Joules per second.
- Practical significance: In real-world applications, this amount of heat could be supplied via various methods—electric heating, combustion, or other thermal sources—depending on the context.

Broader Considerations and Additional Factors

Phase Transition Temperatures and Conditions

While calculating the heat of fusion provides a baseline energy requirement, actual melting depends on reaching the appropriate temperature. Butane's melting point is approximately -138°C , which is notably below room temperature, indicating it exists as a gas or liquid at typical ambient conditions. Therefore, in practical scenarios, the phase change might involve cooling to this temperature before melting occurs.

Note: Butane's phase transitions are sensitive to pressure; under higher pressures, melting points can shift, affecting the energy calculations.

Heat of Vaporization vs. Heat of Fusion

It's important to distinguish between heat of fusion and heat of vaporization:

- Heat of vaporization is much higher for butane ($\sim 365 \text{ J/g}$ at boiling point), indicating more energy is required to convert it from liquid to gas.
- The heat of fusion is just the initial energy input to change from solid to liquid.

Understanding both is essential for comprehensive thermal management of butane in various states.

Application in Real-World Scenarios

- Storage and Transportation: Knowing the heat of fusion assists engineers in designing containers that can withstand phase changes without failure.
- Fuel Efficiency: In fuel applications, phase changes can influence combustion efficiency and safety protocols.
- Environmental Control: In climate-controlled environments, managing the phase of butane can be

critical in preventing accidental releases or explosions.

Limitations and Assumptions in the Calculation

While the calculation appears straightforward, several assumptions underpin its accuracy:

- Pure Substance: The calculation assumes pure butane without impurities, which could alter the heat of fusion.
- Constant ΔH_{fusion} : The value is assumed constant over the temperature range, but in reality, it can vary slightly with temperature and pressure.
- Complete Melting: It presumes all 25 grams of solid butane melts uniformly, which might not happen if the process is not perfectly controlled.
- No Heat Losses: The calculation disregards heat losses to the surroundings, which are inevitable in practical scenarios.

Conclusions and Final Remarks

The calculation of the heat required to melt a specific mass of butane exemplifies fundamental thermodynamic principles that have widespread applications across science and industry. With a heat of fusion of 80.3 J/g, melting 25.0 grams of butane demands approximately 2007.5 Joules of energy—a manageable figure in many industrial contexts but one that underscores the importance of precise thermal control.

Understanding these properties enables engineers, scientists, and safety professionals to optimize

processes, improve safety protocols, and innovate solutions involving phase changes of hydrocarbons like butane. As energy management continues to be a critical concern globally, such fundamental calculations remain at the heart of efficient and safe chemical and thermal engineering practices.

In essence, this seemingly simple question reveals the intricate balance between energy, matter, and phase transitions—an interplay that shapes much of modern technology and industry.

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