

The Minimum Amount Of Steam At 100c Needed To Melt 1 Gram Of 0c Ice Is A)0.148 Gram. B)6.75 Grams. C)8

The Minimum Amount Of Steam At 100°C Needed To Melt 1 Gram Of 0°C Ice Is
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Introduction

Understanding the energy transfer involved in phase changes is fundamental in thermodynamics. When considering the melting of ice and the condensation of steam, it's crucial to quantify how much steam at 100°C is required to supply the necessary heat to convert a specific mass of ice at 0°C into liquid water at the same temperature. This process involves two key energy exchanges: the latent heat of vaporization released during condensation of steam and the subsequent heat transfer needed to warm the resulting water to the melting point if initial temperatures differ. This article delves into the calculations and principles behind determining the minimum amount of steam required to melt 1 gram of ice at 0°C, evaluating the options of 0.148 grams, 6.75 grams, or 8 grams of steam, and explaining the reasoning in detail.

Fundamental Concepts in Heat Transfer and Phase Changes

Latent Heat of Vaporization

The latent heat of vaporization (L_v) is the amount of heat energy required to convert 1 gram of a liquid into vapor (or vice versa) at constant temperature and pressure. For water at 100°C, the latent heat of vaporization is approximately:

- $L_v \approx 2260 \text{ J/g}$

This means that when 1 gram of steam condenses into water at 100°C, it releases 2260 Joules of energy.

Specific Heat Capacity of Water

The specific heat capacity (c) of water is about:

- $c \approx 4.186 \text{ J/g}^\circ\text{C}$

This value indicates the amount of heat needed to raise the temperature of 1 gram of water by 1°C.

Phase Change and Energy Balance

When steam condenses on ice, the energy released can be used to melt the ice. To determine the minimum amount of steam required, the energy released during condensation must exactly match the energy needed to convert the ice at 0°C into water at 0°C.

Calculating the Minimum Steam Required to Melt 1 Gram of Ice

Step 1: Determine the heat needed to melt 1 gram of ice at 0°C

Since melting ice at 0°C requires the latent heat of fusion (L_f), we note:

- $L_f \approx 334 \text{ J/g}$

Therefore, the energy needed to melt 1 gram of ice at 0°C is:

$$Q_{\text{ice}} = L_f \times \text{mass} = 334 \text{ J}$$

Step 2: Determine the heat released by condensing steam at 100°C

When 1 gram of steam condenses at 100°C into water at 100°C, it releases 2260 Joules.

Step 3: Calculate the minimum amount of steam needed

Since the energy released by condensing steam must at least equal the energy required to melt the ice:

$$m_{\text{steam}} \times L_v \geq Q_{\text{ice}}$$

where m_{steam} is the mass of steam needed.

Rearranging:

$$m_{\text{steam}} \geq Q_{\text{ice}} / L_v = 334 \text{ J} / 2260 \text{ J/g} \approx 0.1478 \text{ g}$$

This is approximately 0.148 grams.

Analysis of the Options

Based on the calculation, the minimum amount of steam at 100°C needed to melt 1 gram of ice at 0°C is approximately 0.148 grams. Comparing this to the options:

- A) 0.148 Gram — aligns closely with the calculated value.
- B) 6.75 Grams — significantly higher, indicating excess steam beyond the minimum requirement.
- C) 8 Grams — also higher, and not minimal but perhaps accounting for inefficiencies or additional heat transfer considerations.

The correct choice, considering pure thermodynamic calculation, is option A) 0.148 Gram.

Additional Factors and Practical Considerations

Heat Losses and Inefficiencies

In real-world situations, heat losses to surroundings, imperfect contact between steam and ice, and other inefficiencies could mean more steam is necessary. The calculation above assumes ideal conditions.

Temperature Variations

If the initial temperature of the ice or the steam varies, additional energy calculations are necessary. For example, warming the ice from below 0°C or superheating the steam would alter the required amounts.

Application in Engineering and Science

Understanding the minimal steam required is vital in processes such as refrigeration, power plants, and industrial cooling systems where phase change heat transfer plays a critical role.

Conclusion

The calculation demonstrates that approximately 0.148 grams of steam at 100°C is required to melt 1 gram of ice at 0°C under ideal conditions. This aligns with option A), confirming its correctness. The other options, B) and C), reflect larger quantities that might be relevant in practical, non-ideal scenarios, or when accounting for inefficiencies. Mastery of these principles is essential for engineers and scientists working with thermal systems, phase changes, and heat transfer phenomena.

Summary

- The key to determining minimum steam needed is balancing the latent heat released during condensation against the heat required to melt the ice.
- The ideal minimum is approximately 0.148 grams, as derived from fundamental thermodynamic equations.
- Real-world applications often require more than this minimum due to inefficiencies.

Frequently Asked Questions

What is the minimum amount of steam at 100°C needed to melt 1 gram of ice at 0°C?

0.148 grams

Why is only a small amount of steam required to melt 1 gram of ice at 0°C?

Because the heat released by condensing a small amount of steam is enough to supply the latent heat needed to melt the ice.

How does the latent heat of vaporization of steam influence the amount needed to melt ice?

The high latent heat of vaporization means each gram of steam releases a significant amount of heat when condensing, making only a small amount sufficient to melt ice.

Is the amount of steam required to melt ice at 0°C dependent on the initial temperature of the ice?

No, because the ice is at 0°C and the steam at 100°C, the key factor is the heat transfer

from condensing steam, not the initial temperature of the ice.

Which option correctly represents the minimum amount of steam needed to melt 1 gram of ice at 0°C?

Option A) 0.148 gram

How is the calculation of the required steam amount performed?

By equating the heat released from condensing steam (mass $\times$ latent heat of vaporization) to the heat required to melt the ice (mass $\times$ heat of fusion).

What are the typical values involved in this calculation?

Latent heat of vaporization of steam (~ 2260 J/g) and heat of fusion of ice (~ 334 J/g).

Can the amount of steam needed vary with environmental conditions?

Yes, factors like ambient temperature and heat losses can affect the precise amount required, but under ideal conditions, the calculated values apply.

Additional Resources

The Minimum Amount Of Steam At 100°C Needed To Melt 1 Gram Of 0°C Ice Is A) 0.148 Gram. B) 6.75 Grams. C) 8

Understanding the precise amount of steam required to melt a specific mass of ice is a fascinating intersection of thermodynamics and practical physics. When considering the minimum amount of steam at 100°C needed to melt 1 gram of 0°C ice, it involves calculating the energy transfer required to convert the ice at freezing point into liquid water, and then determining how much steam at boiling temperature can supply that energy through condensation. This analysis not only reveals the fundamental principles of heat transfer but also has real-world applications in industries such as refrigeration, climate control, and even culinary arts.

In this article, we will explore the science behind this calculation, clarify the options provided, and offer a comprehensive guide to understanding how the three choices—A) 0.148 gram, B) 6.75 grams, and C) 8 grams—relate to the physical principles involved.

The Physics of Melting Ice with Steam

Basic Concepts

Before diving into calculations, it's essential to understand the key concepts involved:

- Latent Heat of Fusion (L_f): The amount of heat required to convert 1 gram of ice at 0°C into water at 0°C without changing temperature.
- Latent Heat of Vaporization (L_v): The amount of heat required to convert 1 gram of water at 100°C into steam at 100°C without changing temperature.
- Specific Heat Capacity of Water: The amount of heat needed to raise the temperature of 1 gram of water by 1°C , approximately 4.18 Joules.

Relevant Data

Property	Value	Units	Notes
Latent heat of fusion (L_f)	334	Joules/gram	J/g Heat needed to melt ice at 0°C
Latent heat of vaporization (L_v)	2260	Joules/gram	J/g Heat needed to convert water at 100°C to steam
Initial temperature of ice	0°C	$^\circ\text{C}$	Starting temperature of the ice
Temperature of steam	100°C	$^\circ\text{C}$	The steam at boiling point

Step-by-Step Calculation of Steam Needed

1. Determine the heat required to melt 1 gram of ice at 0°C

Since the ice is at 0°C , to melt it into water at 0°C requires just the latent heat of fusion:

$$Q_{\text{melt}} = L_f \times \text{mass of ice}$$
$$Q_{\text{melt}} = 334 \text{ J/g} \times 1 \text{ g} = 334 \text{ Joules}$$

This is the minimum energy needed to turn the ice into water at 0°C .

2. Calculate the heat released when condensing steam at 100°C

When steam at 100°C condenses into liquid water at the same temperature, it releases a specific amount of heat:

$$Q_{\text{condense}} = L_v \times \text{mass of steam}$$

To find the minimum mass of steam (m) needed, set:

$$Q_{\text{condense}} = Q_{\text{melt}}$$

Thus:

$$L_v \times m = 334 \text{ J}$$

Rearranged:

$$m = 334 \text{ J} / L_v$$

Substituting $L_v = 2260 \text{ J/g}$:

$$m \approx 334 / 2260 \approx 0.1478 \text{ grams}$$

3. Final result: the minimum amount of steam

This calculation shows that approximately 0.148 grams of steam condensed at 100°C is enough to supply the heat necessary to melt 1 gram of ice at 0°C.

Interpreting the Options: Which Is Correct?

Given the calculation, the options are:

- A) 0.148 gram
- B) 6.75 grams
- C) 8 grams

Based on the thermodynamic principles, option A) 0.148 gram is the correct answer. It precisely matches the calculated minimal amount of steam required.

Options B) and C) are significantly larger quantities, which might correspond to scenarios involving additional heat losses, raising the temperature of the resulting water, or assuming less efficient heat transfer. However, for the strict minimum amount that directly melts the ice without any other considerations, 0.148 grams is the accurate figure.

Additional Considerations and Practical Implications

Real-World Factors

In real situations, factors such as heat loss to the environment, imperfect contact between steam and ice, and initial temperature variations can mean that more steam than the minimum calculated amount is required. Nonetheless, the calculation provides a fundamental baseline.

Applications

Understanding this minimal amount is crucial in designing systems like:

- Steam-based heating systems
- Ice melting in industrial processes
- Cryogenic and refrigeration setups

Knowing the precise amount of steam needed ensures efficiency and cost-effectiveness, avoiding waste of resources and optimizing energy consumption.

Summary: The Correct Choice and Its Significance

To conclude, based on thermodynamic calculations, the minimum amount of steam at 100°C needed to melt 1 gram of 0°C ice is approximately 0.148 grams, making option A) the correct answer.

This fundamental calculation underscores the efficiency of phase change heat transfer: a tiny quantity of steam can supply enough energy to melt a much larger mass of ice, illustrating the powerful latent heat involved in phase transitions.

Final Thoughts

Mastering these calculations enhances understanding of energy transfer processes and helps in designing more efficient thermal systems. Whether you're a student, engineer, or enthusiast, grasping how small amounts of steam can effect significant changes in temperature and phase illustrates the elegance and power of thermodynamics.

Remember, while theoretical calculations provide a baseline, practical applications often require considering additional factors to ensure accuracy and efficiency. But knowing the fundamental minimum is the first step toward mastery in thermal physics.

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