The Change In Internal Energy Of A System Is -5.155 KJ. The System Absorbs 2500 J Of Heat.Which Of The

The Change In Internal Energy Of A System Is -5.155 KJ. The System Absorbs 2500 J Of Heat. Which Of The is a question that touches upon fundamental concepts in thermodynamics, particularly the first law of thermodynamics. Understanding how energy transfer and transformation occur within a system is essential for students, scientists, and engineers working with thermal processes. This article aims to clarify the relationship between the change in internal energy, heat transfer, and work done on or by the system, providing clarity through detailed explanations, relevant formulas, and practical examples. Whether you're studying physics, chemistry, or engineering, grasping these principles is crucial for analyzing energy systems effectively.

Understanding Internal Energy and Thermodynamic Systems

What Is Internal Energy?

Internal energy (U) of a system refers to the total energy contained within it due to the microscopic motions and interactions of its particles. This includes kinetic energy from particle motion, potential energy from intermolecular forces, and other forms of microscopic energy. Changes in internal energy are central to understanding energy transfer processes.

What Constitutes a Thermodynamic System?

A thermodynamic system is a well-defined portion of the universe chosen for analysis. It can be:

- Open system: exchanges both energy and matter with surroundings
- Closed system: exchanges only energy, not matter
- Isolated system: exchanges neither energy nor matter

In most thermodynamics problems, the focus is on energy exchange in terms of heat (Q) and work (W).

The First Law of Thermodynamics: Conservation of Energy

Statement of the First Law

The first law of thermodynamics states:

- $\Delta U = Q - W$

Where:
- ΔU = change in internal energy of the system
- Q = heat added to the system (positive if added, negative if removed)
- W = work done by the system (positive if work is done by the system, negative if work is done on the system)

This law emphasizes that the change in a system's internal energy results from heat transfer and work interactions.

Implications of the First Law

- An increase in internal energy occurs when heat is added or work done on the system.
- A decrease in internal energy occurs when heat is removed or work is done by the system.
- The law provides a quantitative way to analyze energy transformations.

Analyzing the Given Data

Given Data Summary

- Change in internal energy, $\Delta U = -5.155$ KJ
- Heat absorbed by the system, Q = 2500 J

Note: Since ΔU is given in kilojoules and heat in joules, it's important to convert units for consistency.

Converting Units for Consistency

- 1 KJ = 1000 J
- $\Delta U = -5.155$ KJ = -5155 J

Now, applying the first law:

$$\Delta U = Q - W$$
$$-5155\ J = 2500\ J - W$$

Solving for W:

$$W = 2500\ J + 5155\ J = 7655\ J$$

This indicates the work done by or on the system during the process.

Interpreting the Significance of the Energy Change

What Does a Negative ΔU Mean?

A negative change in internal energy indicates that the system's internal energy decreases over the process. This could be due to:

- Loss of energy in the form of work done by the system
- Removal of heat (though in this case, heat is absorbed, so the decrease is primarily from work)

Is the Heat Absorbed or Released?

Since the system absorbs 2500 J of heat, the energy input is positive. However, the overall internal energy decreases, which suggests that the system performs significant work on its surroundings.

Work Done by the System

The positive work value (7655 J) indicates that the system does work on the surroundings during the process. This is typical in processes like expansion, where the system pushes against external forces.

Practical Examples and Applications

Example 1: Gas Expanding in a Cylinder

Consider a gas contained within a cylinder that absorbs heat and expands. The gas performs work on the piston, leading to a decrease in internal energy despite heat absorption. Such processes are common in engines and turbines.

Example 2: Endothermic Reactions with Work Output

Certain chemical reactions absorb heat but also involve work done by the system, such as phase changes or chemical expansions, resulting in a net decrease in internal energy.

Applications in Engineering

Understanding the energy dynamics involved in such processes helps engineers design more efficient thermal systems, engines, and refrigerators.

Summary of Key Concepts

- **Change in Internal Energy (ΔU):** Indicates how much energy within a system has increased or decreased.
- **Heat (Q):** Transfer of thermal energy; positive when absorbed, negative when released.
- **Work (W):** Mechanical energy transfer; positive when work is done by the system.
- **First Law of Thermodynamics:** $\Delta U = Q - W$

By applying these principles, one can analyze complex thermodynamic processes, determine the amount of work involved, and better understand energy transformations in real-world systems.

Conclusion

The analysis of the change in internal energy, given the heat absorbed, reveals that the system performs significant work during the process. The negative ΔU indicates a net loss of internal energy, primarily due to work done on the surroundings, despite heat absorption. Understanding these relationships is crucial for thermodynamic analysis and the design of energy-efficient systems. Whether dealing with engines, chemical reactions, or thermal management systems, mastering the principles outlined in this article enables a deeper comprehension of energy flow and transformation.

Further Reading and Resources

- First Law of Thermodynamics Explained
- Thermodynamics in Chemistry
- Energy and Work in Thermodynamics

Understanding the intricate balance of heat, work, and internal energy is fundamental to mastering thermodynamics and its applications across various scientific and engineering disciplines.

Frequently Asked Questions

What is the change in internal energy of the system given?

The change in internal energy of the system is -5.155 kJ.

If the system absorbs 2500 J of heat, what does the negative change in internal energy indicate?

It indicates that the system's internal energy decreases despite absorbing heat, likely due to work done by the system exceeding heat input.

How can we verify the work done by the system using the first law of thermodynamics?

Using the first law, $\Delta U = Q - W$, so $W = Q - \Delta U$. Substituting $Q = 2500$ J and $\Delta U = -5155$ J, $W = 2500$ J $- (-5155$ J$) = 7655$ J, meaning work done by the system is 7655 J.

What is the significance of the negative ΔU in thermodynamics?

A negative ΔU signifies that the system's internal energy decreases over the process, often due to the system performing work on its surroundings or losing heat.

Given the data, what is the work done by or on the system?

The work done by the system is 7655 J, as calculated from the first law of thermodynamics.

Which processes could result in a negative change in internal energy despite heat absorption?

Processes where the system performs significant work or loses heat at a rate greater than the heat absorbed can result in a negative change in internal energy despite heat absorption.

Additional Resources

The Change In Internal Energy Of A System Is -5.155 KJ. The System Absorbs 2500 J Of Heat. Which Of The

Introduction: Understanding the Fundamentals of Internal Energy and Heat Transfer

In the realm of thermodynamics, the concepts of internal energy and heat transfer are fundamental to understanding how energy behaves within physical systems. The given scenario, where a system exhibits a change in internal energy of -5.155 kJ while absorbing 2500 J of heat, presents an intriguing case for analysis. It prompts questions about the nature of the work done, the direction of energy flow, and the overall energy balance within the system.

This article aims to dissect this scenario comprehensively, exploring the principles underlying the observed phenomena, deriving relevant calculations, and analyzing the implications. To do so, we will first clarify key concepts such as internal energy, heat, work, and the first law of thermodynamics before delving into the specifics of the problem.

Section 1: Fundamental Concepts in Thermodynamics

What Is Internal Energy?

Internal energy (U) is a thermodynamic property representing the total energy contained within a system due to microscopic motions and interactions. It encompasses kinetic energy of molecules, potential energy from intermolecular forces, and other forms of microscopic energy. Internal energy is a state function, meaning its change depends only on initial and final states, not the path taken.

Mathematically, an infinitesimal change in internal energy is expressed as:

$$dU = \delta Q - \delta W$$

where:

- δQ is the heat added to the system.
- δW is the work done by the system.

In many practical scenarios, the work can be due to volume changes (PV work) or other forms such as shaft work.

Heat and Work in Thermodynamics

- Heat (Q): Energy transferred between systems due to a temperature difference. It is a path function, meaning its amount depends on the process path, not just initial and final states.
- Work (W): Energy transfer resulting from macroscopic forces acting through a distance. Work can be done in various forms, such as expansion/compression work, electrical work, or shaft work.

The First Law of Thermodynamics

The first law states that energy cannot be created or destroyed; it can only change form. For a closed system, it is expressed as:

$$ \Delta U = Q - W $$

where:

- ΔU: Change in internal energy
- Q: Heat added to the system
- W: Work done by the system

This law forms the backbone of the analysis for our scenario.

Section 2: Analyzing the Given Data

Details of the Scenario

The problem provides two key pieces of information:

1. Change in internal energy (ΔU): -5.155 kJ
2. Heat absorbed (Q): 2500 J

At first glance, there appears to be a discrepancy between the units of heat and internal energy:

- $\Delta U = -5.155\, \text{kJ} = -5155\, \text{J}$
- $Q = 2500\, \text{J}$

This unit consistency is crucial for accurate calculations.

Understanding the Sign Conventions

In thermodynamics, the sign conventions are vital:

- Heat (Q): Positive when heat is added to the system; negative when heat is removed.
- Work (W): Positive when work is done by the system; negative when work is done on the system.
- Change in internal energy (ΔU): Positive if internal energy increases; negative if it decreases.

Given that the system absorbs heat, $Q=+2500\, \text{J}$.

The change in internal energy is negative, indicating an overall decrease in the system's internal energy despite heat absorption, which suggests that work done by the system must be significant.

Section 3: Applying the First Law of Thermodynamics

Using the first law:

$$ \Delta U = Q - W $$

Rearranged to solve for work:

$$ W = Q - \Delta U $$

Substituting the known values:

$$ W = 2500\, \text{J} - (-5155\, \text{J}) = 2500\, \text{J} + 5155\, \text{J} = 7655\, \text{J} $$

This positive value for W indicates that the system does work done by the system during the process, which aligns with the decrease in internal energy.

Key insight: The system absorbs heat but still loses internal energy because it expends a significant amount of energy doing work on its surroundings.

Section 4: Interpreting the Results and Possible Processes

What Does the Calculated Work Signify?

The calculation shows that:

- The system absorbs 2500 J of heat.
- It performs approximately 7655 J of work.

The net effect is a decrease in internal energy:

$$ \Delta U = Q - W = 2500\, \text{J} - 7655\, \text{J} = -5155\, \text{J} $$

This aligns perfectly with the given data.

Implication: The process involves the system doing work on its surroundings, such as expansion, piston movement, or other work forms, leading to a net loss in internal energy despite heat absorption.

What Types of Processes Can Lead to This Scenario?

Several thermodynamic processes could produce these results:

- Expansion at Constant or Variable Pressure: If the system expands, doing work on surroundings, it can lose internal energy even while absorbing heat.

- Adiabatic-like Conditions with Heat Addition: If the process involves heat addition but the work done exceeds the heat absorbed (e.g., rapid expansion or highly work-intensive processes), internal energy can decrease.

- Work-Intensive Processes: Industrial or natural phenomena where energy is primarily spent on doing work rather than increasing internal energy.

Potential Real-World Examples

- Gas Expansion in Engines: An idealized engine process where the gas absorbs heat but does a large amount of work during expansion, resulting in a net decrease in internal energy.

- Chemical Reactions: Exothermic reactions that require work input (e.g., compression) might lead to internal energy decrease despite heat absorption elsewhere.

Section 5: Additional Considerations and Thermodynamic Implications

Energy Conservation and System Boundaries

The analysis underscores the importance of defining system boundaries clearly. If the system performs work during the process, energy conservation still holds. The net energy change reflects the balance between heat absorbed and work done.

Entropy and Irreversibility

While not directly addressed in the problem, the entropy change of the system and surroundings could provide additional insights:

- If the process is reversible, the entropy change is minimized.
- If irreversible, entropy increases, often accompanied by dissipative effects.

Understanding whether the process is reversible or irreversible would influence the interpretation of the energy transfer mechanisms.

Limitations and Assumptions

- The calculations assume a closed system with no mass transfer.
- The process is considered idealized; real systems may involve additional complexities.
- The specific nature of work (e.g., PV work, shaft work) is not specified, but the magnitude suggests significant expansion work.

Section 6: Conclusions and Broader Significance

The scenario analyzed demonstrates the nuanced interplay between heat transfer, work, and internal energy within thermodynamic systems. Despite the system absorbing 2500 J of heat, the negative change in internal energy indicates that the system performed more work than the heat input supplied. This highlights the principle that internal energy can decrease even during heat absorption if the process involves significant work output.

Understanding such energy transformations is crucial across various fields, from engineering design of engines and turbines to natural phenomena like weather systems and planetary processes. It emphasizes the importance of considering all forms of energy transfer and the directionality of processes when analyzing thermodynamic systems.

Furthermore, this analysis exemplifies the importance of the first law of thermodynamics as a powerful tool for quantifying energy flows and predicting system behavior. It underscores that energy conservation remains valid, but the distribution among heat, work, and internal energy can vary significantly based on the process specifics.

In essence, the key takeaway is that in thermodynamics, the apparent paradox of heat absorption accompanied by a decrease in internal energy can be explained through the substantial work performed by the system, reaffirming the intricate balance governing energy transformations.

The Change In Internal Energy Of A System Is 5 155 Kj The System Absorbs 2500 J Of Heat Which Of The

The Change In Internal Energy Of A System Is 5 155 Kj The System Absorbs 2500 J Of Heat Which Of The

Related Articles

- Un Hombre RicoLa Luna Y Las EstrellasEl Sol Y El Aire Que RespiroTus Ojos Y Corazn SinceroTodos Son De
- There Are Two Urns, Urn 1 And Urn 2, Containing A Number Of Red And Blue Balls. More Specifically, Urn
- The Score Of 25 Randomly Selected Exams Are Given Below:58 60 65 67 70 72 73 75 75 75 77 77 7880 80 82

Back to Home