FIRST LAW OF THERMODYNAMICS PRACTICE PROBLEMS

First Law of Thermodynamics Practice Problems: Master Energy Conservation

So, you're tackling the First Law of Thermodynamics? That's fantastic! This fundamental principle of physics, governing the conservation of energy, can seem daunting at first, but with the right approach, it becomes remarkably straightforward. This post is your ultimate guide, packed with first law of thermodynamics practice problems to help you master this crucial concept. We'll move from basic examples to more challenging ones, providing detailed solutions along the way. Get ready to boost your understanding and ace those upcoming exams!

Understanding the First Law: A Quick Refresher

Before diving into the first law of thermodynamics practice problems, let's briefly review the core principle. The First Law essentially states that energy cannot be created or destroyed, only transformed from one form to another. Mathematically, it's expressed as:

$\Delta U = Q - W$

Where:

ΔU represents the change in internal energy of a system. This is the energy stored within the system itself.
Q represents the heat added to the system. A positive Q indicates heat added, while a negative Q indicates heat removed.
W represents the work done by the system. A positive W indicates work done by the system, while a negative W indicates work done on the system.

Remember the sign conventions – they're crucial for accurately solving problems.

First Law of Thermodynamics Practice Problems: Beginner Level

Let's start with some simpler problems to build your confidence.

Problem 1: A system absorbs 100 J of heat and does 40 J of work. What is the change in internal energy of the system?

Solution: We use the formula: $\Delta U = Q - W$. Q = +100 J (heat added), W = +40 J (work done by the system). Therefore, ΔU = 100 J - 40 J = 60 J. The internal energy of the system increases by 60 J.

Problem 2: A gas is compressed, and 50 J of work is done on the system. The internal energy of the gas increases by 80 J. How much heat is exchanged with the surroundings?

Solution: Here, W = -50 J (work done on the system), and ΔU = +80 J. Using the formula, we have: 80 J = Q - (-50 J). Solving for Q, we get Q = 30 J. This means 30 J of heat is released by the system to the surroundings.

Problem 3: A system undergoes a process where its internal energy decreases by 25 J, and it releases 15 J of heat. How much work is done by the system?

Solution: ΔU = -25 J (internal energy decreases), Q = -15 J (heat released). Using the formula, -25 J = -15 J - W. Solving for W, we get W = 10 J. The system does 10 J of work.

First Law of Thermodynamics Practice Problems: Intermediate Level

Now let's tackle some problems that require a bit more thinking.

Problem 4: An ideal gas expands adiabatically (no heat exchange) and does 200 J of work. What is the change in the internal energy of the gas?

Solution: Since the process is adiabatic, $Q = 0$. Therefore, $\Delta U = 0 - 200\ J = -200\ J$. The internal energy of the gas decreases by 200 J. This decrease in internal energy is directly converted into the work done by the gas.

Problem 5: A piston-cylinder system contains 1 mole of an ideal gas. The gas is heated at constant pressure, absorbing 500 J of heat. The gas expands, doing 200 J of work. What is the change in internal energy of the gas?

Solution: $Q = +500\ J$, $W = +200\ J$. Therefore, $\Delta U = 500\ J - 200\ J = 300\ J$. The internal energy of the gas increases by 300 J.

Problem 6: A system undergoes a cyclic process. The net work done by the system is 150 J. What is the net heat exchanged during the cycle?

Solution: In a cyclic process, the system returns to its initial state, meaning $\Delta U = 0$. Therefore, $0 = Q - W$. Since $W = 150\ J$, $Q = 150\ J$. The net heat added to the system during the cycle is 150 J.

First Law of Thermodynamics Practice Problems: Advanced Level

Problem 7: A heat engine absorbs 800 J of heat from a high-temperature reservoir and does 300 J of work. How much heat is expelled to a low-temperature reservoir? What is the efficiency of this engine?

Solution: The heat absorbed is $Q_{in} = 800\ J$, and the work done is $W = 300\ J$. Using the First Law, $\Delta U = 0$ for a complete cycle (we're assuming it's a complete cycle for this heat engine). Therefore, $Q_{in} = W + Q_{out}$. Solving for Q_{out} (heat expelled), we get $Q_{out} = 800\ J - 300\ J = 500\ J$. The efficiency is given by $(W / Q_{in})\ 100\% = (300\ J / 800\ J)\ 100\% = 37.5\%$.

Problem 8: A refrigerator absorbs 200 J of heat from a low-temperature reservoir and expels 300 J of heat to a high-temperature reservoir. How much work must be done on the refrigerator?

Solution: The work done on the refrigerator is W. $Q_{in} = 200\ J$, $Q_{out} = -300\ J$ (heat expelled). $\Delta U = 0$ for a complete cycle. Therefore, $0 = 200\ J - 300\ J - W$, Solving for W, we find $W = -100\ J$ (meaning 100 J of work must be done on the refrigerator).

Conclusion

By working through these first law of thermodynamics practice problems, you've significantly improved your understanding of energy conservation. Remember to practice consistently, focusing on the sign conventions and applying the formula correctly. With enough practice, you'll confidently solve even the most complex problems. Keep practicing and remember – mastery comes with persistent effort!

FAQs

1. What happens if work is done on the system instead of by the system?

The work term (W) becomes negative in the equation. This indicates that energy is being added to the system through work.

1. Can the internal energy of a system be negative?

Internal energy is a relative measure; it's the energy content relative to a reference point. While a change in internal energy can be negative, the absolute internal energy is always positive.

1. How does the First Law relate to other laws of thermodynamics?

The First Law is the foundation upon which the other laws are built. The Second Law deals with the direction of energy transfer, and the Third Law deals with absolute zero.

1. Are there any exceptions to the First Law of Thermodynamics?

No, the First Law is a fundamental principle of physics, and no verifiable exceptions have been found.

1. How can I improve my problem-solving skills in thermodynamics?

Practice consistently with various problem types, understand the underlying concepts, draw diagrams, and check your units at each step of the calculation. Seek help when needed and don't be afraid to ask questions.

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