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MCHS Honors Physics 2013-2014

The First Law of Thermodynamics 1

Remember: $\Delta U = Q - W$. That is, the change in the system's INTERNAL ENERGY equals the energy transferred into or out of the system as HEAT minus the energy transferred into or out of the system as WORK.

Example: A total of $135\,J$ of work is done on a gaseous refrigerant as it undergoes compression. If the internal energy of the gas increases by $114\,J$ during the process, what is the total amount of energy transferred as heat? Has energy been added or removed from the refrigerant as heat?

Given: $W = -135\,J$ ← Work is done on the gas, so work (W) has a negative value.

$\Delta U = 114\,J$ ← The internal energy increases during the process, so the change in internal energy (ΔQ) has a positive value.

Unknown: $Q = ?$

Apply the 1st law of thermodynamics, $\Delta U = Q - W$

$\Delta U = Q - W \rightarrow Q = \Delta U + W$ ← rewrite the equation to solve for Q

$Q = 114\,J + (-135\,J) = -21\,J$ ← plug in the values of W and ΔU given

$\boxed{Q = -21\,J}$

The negative sign of this answer indicates that energy is transferred as heat from the refrigerant. $135\,J$ of energy were added as work, but the refrigerant only increased in internal energy by $114\,J$. The remaining $21\,J$ of the energy from work was given of as heat.

Problems:

1. Heat is added to a system and the system does $26\,J$ of work (W). The sign of this value is positive, indicating that work is done by the gas. If the internal energy of the system increases by $7\,J$ (ΔU), how much heat was added to the system?

2. The internal energy of the gas in a gasoline engine's cylinder decreases by $195\,J$. If $52\,J$ of work is done by the gas, how much energy is transferred as heat? Is this energy added to or removed from the gas?

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3. A quantity of water is held at a constant volume is a pressure cooker and heated on a stove. As a result of this heating, the system's internal energy increases by $8.0\times10^3\ J$. However, the pressure cooker is not well insulated, and as a result, $2.0\times10^3\ J$ of energy is also transferred from the pressure cooker to the environment. How much total energy is transferred from the stove to the pressure cooker as heat?

4. The internal energy of a gas decreases by $344\ J$. If the process is **adiabatic**, how much energy is transferred as heat? How much work is done on or by the gas?

5. A steam engine's boiler completely converts $155\ kg$ of water into steam, transferring $3.5\times10^8\ J$ as heat. If steam escaping through a safety valve does $1.76\times10^8\ J$ of work expanding against the outside atmosphere, what is the net change in the internal energy of the water-steam system?