SAMPLE PROBLEM B

The First Law of Thermodynamics

PROBLEM

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 to or removed from the refrigerant as heat?

SOLUTION

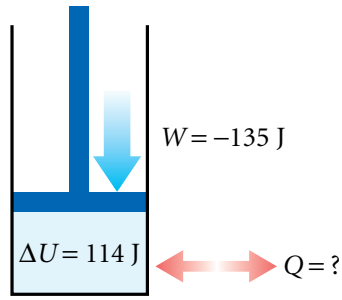
1. DEFINE

Given: $W = -135\ \text{J}$ $\Delta U = 114\ \text{J}$

Unknown: $Q = ?$

TIP *Work is done on the gas, so work (W) has a negative value. The internal energy increases during the process, so the change in internal energy (ΔU) has a positive value.*

Diagram:



2. PLAN

Choose an equation or situation:

Apply the first law of thermodynamics using the values for ΔU and W in order to find the value for Q.

$$\Delta U = Q - W$$

Rearrange the equation to isolate the unknown:

$$Q = \Delta U + W$$

3. CALCULATE

Substitute the values into the equation and solve:

$$Q = 114\ \text{J} + (-135\ \text{J}) = -21\ \text{J}$$

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

TIP *The sign for the value of Q is negative. From* ***Table 1****, Q < 0 indicates that energy is transferred as heat from the refrigerant.*

4. EVALUATE

Although the internal energy of the refrigerant increases under compression, more energy is added as work than can be accounted for by the increase in the internal energy. This energy is removed from the gas as heat, as indicated by the minus sign preceding the value for Q.