Thermodynamics

A refrigerator which has a coefficient of performance one-third that of a Carnot refrigerator is operated between two reservoirs at temperatures of 230° K and 360° K. It absorbs 700 J from the low-temperature reservoir. How much heat is rejected at the high-temperature reservoir?

Solution

The coefficient of performance of a Carnot refrigerator is defined as the ratio of heat extracted from the source of cold and the work needed to run the cycle.

$$E_c := \frac{Q_1}{Q_2 - Q_1} \qquad \text{or equivalently} \qquad Ec := \frac{T_1}{T_2 - T_1}$$

Where Q_1 is the heat absorbed at temperature T_1, and Q_2 is the heat rejected at the higher temperature (T_2).

Here are all the temperatures, T, which are to be expressed in Kelvin degrees. The actual refrigerator has a coefficient of performance

$$\frac{Q_1}{Q_2 - Q_1} := \frac{1}{3} \cdot \frac{T_1}{T_2 - T_1}$$

$$Q_1 := 700\ J \qquad T_1 := 230\ K \qquad T_2 := 360\ K$$

$$Ec := \frac{T_1}{T_2 - T_1}$$

$$Q_2 := \frac{3\ Q1}{Ec} + Q_1$$

$$Q_2 = 1886.956\ J$$