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Problem 25.31 (RHK)

A sample of n moles of an ideal gas undergoes an isothermal expansion. We have to find the heat flow into the gas in terms of the initial and final volumes and the temperature.

Solution:

Equation of state of an ideal gas is

$$p = \frac{nRT}{V},$$

where n is the amount of gas in moles, T its temperature, and V its volume. Work done on an ideal gas under isothermal expansion will be given by

$$W = - \int_{V_i}^{V_f} p dV = - \int_{V_i}^{V_f} \frac{nRT}{V} dV = -nRT \ln \left(\frac{V_f}{V_i} \right).$$

In an isothermal process there is no change in the internal energy. The first law of thermodynamics is

$$\Delta E = Q + W.$$

As $\Delta E = 0$,

We have

$$W = -Q = nRT \ln\left(\frac{V_f}{V_i}\right).$$

