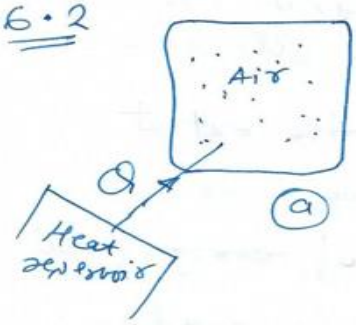
6.2



(a)

rigid $\Delta V = 0$

$Q = \cancel{W}^{\,0} + (\Delta U)$ first law

$Q_{\text{to air}} = U_2 - U_1 = m(u_2 - u_1)$

$= m c_v (T_2 - T_1)$

$= 1500 \times 0.171 \times 40$

$= 10260$ Btu

(b) $Q_{HR} = -Q_{\text{to air}} = 10260$ Btu

$\Delta S_{\text{total}} = \Delta S_{\text{sys}} + \Delta S_{\text{Heat reservoir}}$

$= \Delta S_{\text{gas (ideal)}} + \Delta S_{HR}$

$= m c_v \ln \frac{T_2}{T_1} + \cancel{R \ln \frac{V_2}{V_1}}^{\,0\ (V_2 = V_1)} + \frac{(-10260)}{760}$

760: $300\,°F = 760\,°R$ (Rankine, unit of temp.)

$\Delta S_{\text{total}} = (1500)(0.171) \ln \frac{540}{500} - \frac{10260}{760}$

$= 6.24$ Btu/°R

(c) we want to achieve the same goal (heating gas from $500 \rightarrow 540$ °R) using work reservoir.

$\Delta S_{\text{total}} = \Delta S_{\text{air}} + \cancel{\Delta S_{\text{work reservoir}}}^{\,0}$

$= m c_v \ln \frac{T_2}{T_1} + 0 = 19.74$ Btu/°R

if we compare (c) with (b), we are generating more entropy as we are taking the gas to more disorganized state by spending work (high grade energy) in case of (c), whereas (providing) in part (b) we are extracting heat (low grade energy) from a hot reservoir,

The important concept to learn in this problem is as follows:-
in order to increase the extent of disorderness/disorganization, one should spend lower grade of energy (heat) rather than spending higher grade energy (work).

If we are using work to increase internal energy of an object (like gas), we are converting organized (useful) form of energy to disorganized (not useful in framework of thermodynamics) form of energy, Therefore we are creating more entropy, or in other words we are decreasing the quality of energy by converting work into internal energy.