Solution The inlet conditions are known and from steam tables we find:

$$H_1 = 3445.8 \text{ kJ/kg}, \quad S_1 = 7.0919 \text{ J/kg K}.$$

Reversible work. The reversible work corresponds to isentropic operation between $T_1 =$ 500 C, P_1 =40 bar, and $P_2 = 1$ bar. The outlet state is defined by the conditions, $P_{2'} = P_2 = 1$ bar, $S_{2'} = S_1 = \cancel{7.361}$ J/kg K. This state is in the vapor liquid region. From the steam tables at 1 bar, 99.61 C, we find

7.0919

	H (kJ/kg)	S (kJ/kg/K)
L	417.44	1.3026
V	2674.9	7.3588

The vapor fraction is

$$x_V = \frac{S_{2'} - S_L}{S_V - S_L} = \frac{7.0919 - 1.3026}{7.3588 - 1.3026} = 0.9559.$$

The enthalpy of the outlet stream is calculated using the lever rule,

$$\begin{aligned} H_{2'} &= x_V H_V + (1 - x_V) H_L = (0.9559)(2674.9) + (1 - 0.9559)(417.44) \\ &= 2575.41 \text{ kJ/kg}, \end{aligned}$$

and the reversible work is

$$W_s^{\text{rev}} = H_{2'} - H_1 = 2575.41 - 3445.8 = -870.387 \text{ kJ/kg}.$$

Actual operation. The actual work is

$$W_s = \eta W_s^{\text{rev}} = (0.8)(-870.387) = -696.31 \text{ kJ/kg}.$$

With this we now calculate the enthalpy in the actual exit stream:

2749.49

$$H_2 = H_1 + W_s = 3445.8 + (-696.31) = \cancel{2575.41} \text{ kJ/kg}.$$

The exit state is now fully defined by its pressure (1 bar) and enthalpy (3445.8 kJ/kg). Its temperature and entropy are obtained from the table by interpolation. The exit state as well as the inlet and reversible outlet states are summarized below:

	Inlet	Outlet	Outlet (rev.)
P (bar)	40	1	1
T (K)	500	136.553	99.61
H (kJ/kg)	3445.8	2749.49	2575.41
S (kJ/kg K)	7.0919	7.54647	7.0919