

# HW 4 Solutions

20.26. a) IRREVERSIBLE. WARM WATER NEVER separates into HOT + COLD!

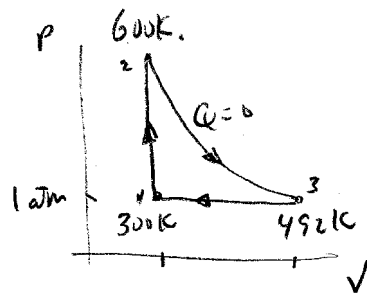
b)  $m_1 c \Delta T_1 + m_2 c \Delta T_2 = 0$

$270 \cdot c \cdot (T - 30^\circ\text{C}) + 30 \cdot c \cdot (T - 100^\circ\text{C}) = 0 \quad T = 37^\circ\text{C}$

c)  $\Delta S = m c \ln \frac{T_f}{T_i} = 25777 \text{ J/K} \quad \text{cold} \rightarrow \text{warm}$   
 $= -23200 \text{ J/K} \quad \text{hot} \rightarrow \text{warm}$   
 $\Rightarrow 2577 \text{ J/K} \text{ total } \Delta S.$

20.40 a) I choose to find volumes, then P.

$V_1 = \frac{nRT_1}{P_1} = 8.61 \text{ L} \quad V_3 = 14.12 \text{ L}$   
 $= V_2$



$P_2 V_2^\gamma = P_3 V_3^\gamma \quad \gamma = 1.4 \quad P_2 = 2 \text{ atm}$

b)  $Q_{12} = n C_V \Delta T = 0.35 \cdot \frac{5}{2} R \cdot (300\text{K}) = 2179 \text{ J}$  }  $= \Delta U_{12}$   
 $W_{12} = 0$   
 $Q_{23} = 0$

$Q_{31} = -n C_p \Delta T = 0.35 \cdot \frac{7}{2} R \cdot (300 - 492\text{K}) = -1952 \text{ J}$  }  $\Delta U_{31} = Q - W = -1388 \text{ J}$   
 $W_{31} = p \Delta V = -1 \text{ atm} \cdot 5.51 \text{ L} = -564 \text{ J}$

$Q_{\text{TOT}} = 227 \text{ J} = W_{\text{TOT}} \text{ (since } \Delta U = 0) \text{ so } W_{23} = 791 \text{ J}$  }  $\Delta U_{23} = -791 \text{ J}$   
 $Q_{23} = 0$

c) 227 J. d) 227 J. not heat  
 Total flow in = 2179 J.

e) efficiency =  $\frac{W}{Q_{\text{in}}} = \frac{227}{2179} = 10.4\%$   $e_c = 1 - \frac{300}{600} = 50\%$

$$20.46 \quad W_{\text{net}} = p_0 V_0 \quad (\text{area in loop})$$

$$Q_{\text{in}} = Q_{12} + Q_{23} = n C_V \Delta T_{12} + n C_P \Delta T_{23}$$

$$\left. \begin{aligned} \Delta p_{12} \cdot V_0 &= n R \Delta T_{12} \\ p_{23} \Delta V_{23} &= n R \Delta T_{23} \end{aligned} \right\}$$

$$= \frac{C_V \Delta p_{12} V_0}{R} + \frac{C_P (2p_0) \Delta V_{23}}{R}$$

$$= \frac{C_V}{R} \cdot p_0 V_0 + \frac{C_P}{R} \cdot 2p_0 V_0$$

$$= \left( \frac{5}{2} + 2 \cdot \frac{7}{2} \right) p_0 V_0 = \frac{19}{2} p_0 V_0$$

$$e = \frac{W}{Q_{\text{in}}} = \frac{2}{19}$$