

right:

$$E_{cf} - E_{ci} + \int \dot{m} e = -P_f V_c$$

$$m_{cf} C_v T_{cf} - m_{ci} C_v T_{ci} + \int \dot{m} e = -P_f V_c$$

$$m = PV$$

$$P_{cf} V_c C_v T_{cf} - P_{ci} V_{ci} C_v T_{ci} + \int \dot{m} e = -P_f V_c$$

left:

$$E_f - E_i - \int \dot{m} e = 0$$

due to $\overbrace{P_{cf} V_c}^{P_f V_c}$
 $\overbrace{P_{ci} V_{ci}}^{P_f V_c}$
 $\rightarrow m, V, e \text{ same.}$

$$m_f C_v T_f - m_i C_v T_i = \int \dot{m} e$$

$$P_f V C_v T_f - P_i V C_v T_i = \int \dot{m} e$$

substitute:

$$P_{cf} V_c C_v T_{cf} + P_f V C_v T_f - P_i V C_v T_i = -P_f V_c$$

divide by V and change $P_T \rightarrow \frac{P}{R}$

$$C_v \left\{ \frac{P_{cf}}{R} \frac{V_c}{V} + \frac{P_f}{R} - \frac{P_i}{R} \right\} = -P_f \frac{V_c}{V}$$