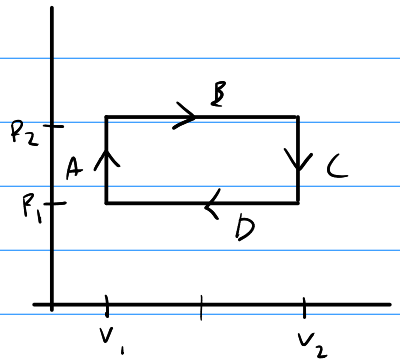
4.1



$W = P_2 \cdot \Delta V - P_1 \Delta V$

$= 2V_1 \cdot (P_2 - P_1)$

$= 2V_1 P_1$

$e = \frac{W}{Q_H} = \frac{2 V_1 P_1}{\frac{33}{2} V_1 P_1} = \frac{4}{33} = 12\%$

(b) $T_C = \frac{P_1 V_1}{NR}$

$T_H = \frac{P_2 V_2}{NR} = \frac{6 P_1 V_1}{NR}$

$e = 1 - \frac{T_C}{T_H} = \frac{5}{6} = 83\%$

A: $W = 0$ $\quad P_2 = 2P_1$

$Q = \Delta U$ $\quad \Delta P = 2P_1 - P_1 = P_1$

$= \frac{5}{2} NR \Delta T = \frac{5}{2} V_1 \Delta P$

$= \frac{5}{2} V_1 P_1$

B: $Q = C_p \Delta T = \frac{7}{2} NR \Delta T$

$= \frac{7}{2} P_2 \Delta V$

$= \frac{7}{2} P_2 (V_2 - V_1)$

$= 7 P_2 V_1 = 14 P_1 V_1$

$Q_H = \frac{5}{2} V_1 P_1 + 14 P_1 V_1$

$= \frac{33}{2} V_1 P_1$

4.2. (a) $e = 1 - \frac{T_C}{T_H}$

$= 1 - \frac{293\,K}{773\,K}$

$= 62.1\%$

(b) $e = 1 - \frac{293\,K}{873\,K}$

$= 66.4\%$

$\frac{66.4}{66.1} = 1.06992$

0.06992 GW more

$\Delta \$ = 62.92\,kW \cdot 365\,days \cdot 24\,h \cdot \$0.05$

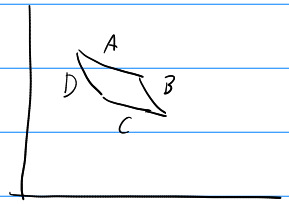
$= \$30625$

4.5. A: $W = -\int_{V_1}^{V_2} P\,dV$

$P = \frac{NRT_H}{V}$ $\quad \therefore W = -NRT_H \int_{V_1}^{V_2} \frac{dV}{V}$

$= NRT_H \ln \frac{V_1}{V_2}$

$Q_H = -W$



B: $\Delta U = W$

$= -\frac{f}{2} Nk (T_H - T_C)$

C: $W = NkT_C \ln \frac{V_3}{V_4}$

$Q_C = W$

D: $\Delta U = W = -\frac{f}{2} Nk (T_H - T_C)$

$VT^{f/2} = \text{const}$ during B and D

$V_2 T_H^{f/2} = V_3 T_C^{f/2}$

$V_1 T_H^{f/2} = V_4 T_C^{f/2}$

$\frac{V_2}{V_1} = \frac{V_3}{V_4}$

$e = 1 - \frac{Q_C}{Q_H} = 1 - \frac{NkT_C \ln \frac{V_3}{V_4}}{NkT_H \ln \frac{V_2}{V_1}}$

$= 1 - \frac{T_C}{T_H}$

4.7. The air conditioner need to expel heat taken from the room and expelling it into the room would not help cool the room.

4.8. No, because the refridgerator will return the heat to the room.