CHAPTER 15

15-1 (a) $W = +1.6\times10^{4}\ J$

(b) $\Delta U = -4.2\times10^{4}\ J$

(c) $\Delta U = Q - W$

$Q = \Delta U + W = -4.2\times10^{4}\ J + 1.6\times10^{4}\ J$

$Q = -2.6\times10^{4}\ J$

15-3 (a) $\Delta U_s = Q_s - W_s$

$= +77\ J - 164\ J = -87\ J$

(b) $\Delta U_e = Q_e - W_e$

$= -77\ J - (-164\ J) = +87\ J$

15-5 Gasoline supplies $1.19\times10^{8}\ J/gal$

Energy available for work $= 1.19\times10^{8}\ J - 1.00\times10^{8}\ J$

$= 0.19\times10^{8}\ J$ per gal

$6.0\times10^{5}\ J$ required per mile,

so $\#\text{miles/gal} = \dfrac{1.9\times10^{7}\ J/gal}{6.0\times10^{5}\ J/mile}$

$= 31.7$ mpg

15-6

$\Delta U = Q - W$

$= 2438\,J - (-962\,J) = +3400\ J$

$\Delta U = \frac{3}{2} n R \Delta T = \frac{3}{2} n R (T_f - T_i)$

$\frac{3}{2}(3)(8.31)(T_f - 345K) = 3400$

$37.4(T_f - 345) = 3400$

$37.4\,T_f - 12901 = 3400$

$T_f = 436\ K$

15-11 Isobaric (constant P) process

$W = P\Delta V = P(V_f - V_i)$

$480\,J = 1.6\times10^{5}\,Pa\,(V_f - 1.5\times10^{-3}\,m^3)$

$V_f - 1.5\times10^{-3} = 3.0\times10^{-3}\,m^3$

$V_f = 4.5\times10^{-3}\,m^3$

15-13 Work = area under P-V plot

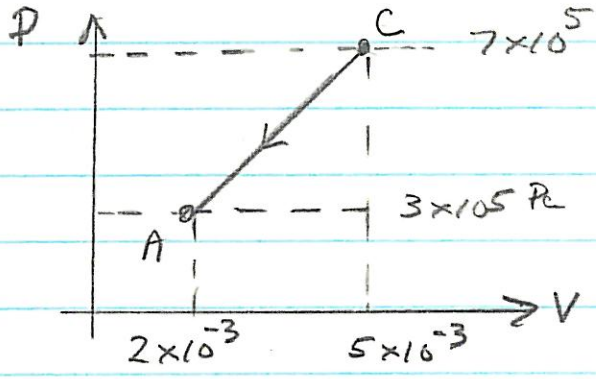
(a) $A \to B$, $\Delta V = 0$, so $W = 0$

(b) $B \to C$, gas expands at constant P

$$W = P\Delta V = 7.0\times10^{5}\ Pa\,(5.0\times10^{-3} - 2.0\times10^{-3})$$

$$= +2.1\times10^{3}\ J$$

(c) $C \to A$, gas is compressed, $W < 0$



Work = area under line CA

$$= \frac{1}{2}(4\times10^{5}\ Pa)(2\cdot10^{-3} - 5\cdot10^{-3}) + (3\times10^{5})(2\cdot10^{-3} - 5\cdot10^{-3})$$

$$= -600 - 900 = -1500\ J$$

15-15

$\Delta U = Q - W$

$W = Q - \Delta U = 1500\,J - 4500\,J$

$W = -3000\,J = P(V_f - V_i)$

$-3000 = P(-0.01\,m^3)$

$P = 3 \times 10^5\,Pa$

15-20 $\Delta U = Q - W = -W$ (Q=0, ADIABATIC)

$\Delta U = \frac{3}{2} n R \Delta T$

$= \frac{3}{2}(5)(8.31)(290 - 370)$

(b) $= -4986\,J$

(a) So / $-W = -4986$

$W = +4986\,J$

15-23 $\Delta U = Q - W$

$\Delta U = \frac{3}{2} n R \Delta T = 0$, since $\Delta T = 0$

$\therefore Q = W \Rightarrow W = Q = -4700\,J$

15-45 $W = Q_H - Q_C$

$Q_H = W + Q_C = 16600 + 9700 = 26300\,J$

$e = \frac{W}{Q_H} = \frac{16600}{26300} = 0.631$

15-47 $e = W/Q_H = W/1300\,J$

$e \rightarrow 1.05e \qquad W = 1.05(1300) = 1365\,J$

Change = 65 J

15-49 $e = \frac{W}{Q_H}$, $W = Q_H - Q_C$

$e = 1 - Q_C/Q_H$

$\frac{Q_C}{Q_H} = 1 - e$, $Q_{H1} = Q_{H2}$

$(Q_C/Q_H)_1 = 1 - e_1 = 1 - 0.23 = 0.77$

$(Q_C/Q_H)_2 = 1 - e_2 = 1 - 0.42 = 0.58$

$\frac{Q_{C2}}{Q_{C1}} = \frac{0.58}{0.77} = 0.75$

15-51

$e_1 = 1 - T_{C1}/T_{H1}$ $\quad T_{C1} = 275\,K$

$T_{H1} = T_{H2} = T_H$

$e_2 = 1 - T_{C2}/T_{H2}$

$\frac{T_{C1}}{T_H} = 1 - e_1 = 1 - 0.27 = 0.73$

$\frac{T_{C2}}{T_H} = 1 - e_2 = 1 - 0.32 = 0.68$

$T_{C2}/T_{C1} = 0.68/0.73 = 0.93$

$T_{C2} = 0.93(275) = 256\,K$

15-53

$e_{carnot} = 1 - T_C/T_H$, $T_C = 378\,K$

(a) $T_C/T_H = 1 - e_{carnot} = 1 - 0.7 = 0.3$

$T_H = T_C/0.3 = 1260\,K$

(b) $\frac{T_H}{T_C} = \frac{Q_H}{Q_C}$

$Q_H = \frac{T_H}{T_C} Q_C = \frac{1260}{378} \cdot 5230$

$= 17433\,J$

15-55

$$W = Q_H - Q_C$$

$$18500 = Q_H - 6550 \Rightarrow Q_H = 25{,}050\ \text{J}$$

If engine is CARNOT, $\frac{T_H}{T_C} = \frac{Q_H}{Q_C}$

$$T_H = T_C \frac{Q_H}{Q_C} = 285 \cdot \frac{25050}{6550} = 1090\ \text{K}$$

15-83

$$\Delta U = Q - W$$

$$= +1200\ \text{J} - (+2500\ \text{J})$$

$$= -1300\ \text{J}$$

(a) $\Delta U = 3/2\, n R \Delta T$

$$\Delta T = \frac{\Delta U}{\frac{3}{2} n R}$$

$$= \frac{-1300}{\frac{3}{2}\left(\frac{1}{2}\right)(8.31)}$$

$$= -208.6\ ^\circ\text{K}$$

(b) decrease