PHYS 262 — Homework 9 (Ch22) — Spring '03

1. (SB 1) (a)

$$e = \frac{W}{Q_h} = \frac{25.0\,J}{360\,J} = 6.94\,\% \#$$

(b)

$$Q_h - Q_c = W \Rightarrow Q_c = Q_h - W = 335\,J \#$$

2. (SB 14)

(a) For adiabatic process

$$P_i V_i^{\gamma} = P_f V_f^{\gamma} \Rightarrow \frac{V_f}{V_i} = \left(\frac{P_f}{P_i}\right)^{-\frac{1}{\gamma}}$$

By the Ideal Gas Law

$$\frac{P_i V_i}{T_i} = \frac{P_f V_f}{T_f} \Rightarrow T_f = T_i \frac{P_f}{P_i}\frac{V_f}{V_i}$$

$$= T_i \left(\frac{P_f}{P_i}\right)^{1-\frac{1}{\gamma}}$$

$$= 564\,K \# \quad (\gamma = \tfrac{5}{3} \text{ for Argon})$$

(b)

$$\Delta E_{int} = Q - W = -W \quad (\because Q = 0)$$

$$\therefore W = -\Delta E_{int} = -n C_v \Delta T$$

$$\text{Power} = \frac{W}{t} = -\frac{n}{t} C_v \Delta T$$

$$\Delta T = 564\,K - 1073\,K \qquad \frac{n}{t} = \frac{80\,kg}{0.0399\,kg}\,\frac{1}{60\,sec.}$$

$$C_v = \tfrac{3}{2}R \quad (\because C_v = \tfrac{R}{\gamma - 1})$$

$$\therefore \text{Power} = 212\,kW \#$$

(c)

$$e = 1 - \frac{T_c}{T_h} = 1 - \frac{564\,K}{1073\,K} = 47.5\,\% \#$$

3. (SB 20) (a) Efficiency of Otto engine, $e = 1 - \left(\frac{V_2}{V_1}\right)^{\gamma - 1}$

Compression ratio $= 6 \Rightarrow \frac{V_2}{V_1} = \frac{1}{6}$

$$\therefore e = 51.2\,\% \#$$

(b) fraction of fuel wasted $= (51.2 - 15)\%$

$$= 36.2\,\% \#$$

4. (SB 35)

$$\Delta S = \frac{Q_2}{T_2} + \frac{(-Q_1)}{T_1} = \frac{1000\,J}{290\,K} - \frac{1000\,J}{5700\,K} = 3.27\,J/K \#$$

5. (SB 40)

(a)

$$P_i V = n R T_i \Rightarrow V = \frac{n R T_i}{P_i} = 39.4\,L \# \quad \left(n = \frac{40.0\,g}{39.9\,g}\right)$$

(b)

$$\Delta E_{int} = n C_v \Delta T$$

$$= -2.50\,kJ \# \quad \left(C_v = \frac{R}{\gamma - 1} = \tfrac{3}{2}R\right)$$

(c) $\because V = \text{constant}, \therefore W = 0$

$$\Delta E_{int} = Q - W \Rightarrow Q = -2.50\,kJ \#$$

(d)

$$\Delta S_{Argon} = \int_i^f \frac{dQ}{T} = \int_i^f \frac{n C_v\, dT}{T} = n C_v \ln \frac{T_f}{T_i}$$

$$= -6.87\,J/K \#$$

(e)

$$\Delta S_{bath} = \frac{2.50\,kJ}{273\,K}$$

(recall that the temperature of heat bath is a constant)

$$= 9.16\,J/K \#$$