ME 200 Homework 3

James Liu

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1. a) $P_{ini} = P_{final} = \boxed{2 \text{ bar}}$,
   $W = p \times \Delta V = 2 \times (0.04 - 0.1) \times 10^5 = \boxed{-12000 \text{ J}}$

   b) $P_{ini}V_{ini} = P_{final}V_{final}$, $P_{ini} = \frac{2 \times 0.04}{0.1} = \boxed{0.8 \text{ bar}} = 8 \times 10^4$ Pa

$$
\begin{aligned}
pV &= 8000 \\
&\text{Thus:} \\
p &= 8 \times 10^3 \times V^{-1} \\
&\text{Thus:} \\
W &= \int_{V_{ini}}^{V_{final}} p \, \mathrm{d}V \\
&= \int_{0.1}^{0.04} 8 \times 10^3 \times V^{-1} \, \mathrm{d}V \\
&= 8 \times 10^3 \times \ln(V)|_{0.1}^{0.04} \\
&= \boxed{-7330.33 \text{ J}}
\end{aligned}
$$

   c) $P_{ini}V_{ini}^{1.3} = P_{final}V_{final}^{1.3}$, $P_{ini} = \frac{2 \times 0.04^{1.3}}{0.1^{1.3}} = \boxed{0.607726 \text{ bar}}$

$$
\begin{aligned}
pV^{1.3} &= 3045.85 \\
&\text{Thus:} \\
p &= 3045.85 \times V^{-1.3} \\
&\text{Thus:} \\
W &= \int_{0.04}^{0.1} 3045.85 \times V^{-1.3} \, \mathrm{d}V \\
&= 3045.85 \times -\frac{10}{3} V^{-0.3}|_{0.1}^{0.04} \\
&= \boxed{-6409.13 \text{ J}}
\end{aligned}
$$

2.

$$p_1 V_1^n = p_2 V_2^n$$
$$\frac{5}{72} \times 4.934^n = \frac{1}{36} \times 11.04^n$$
$$n = 1.13772$$

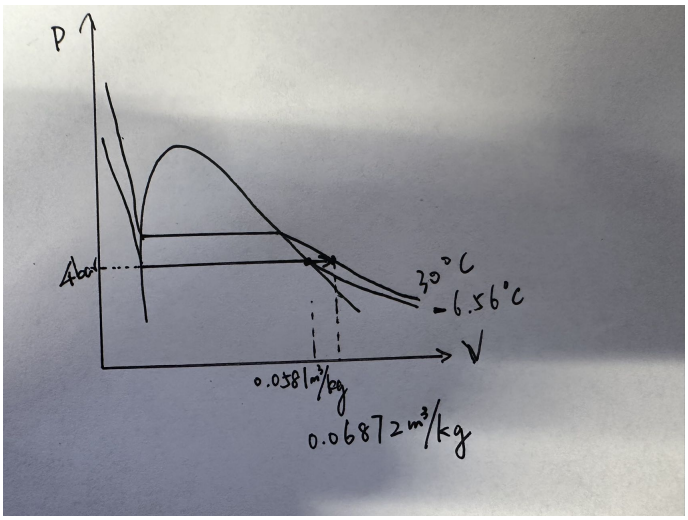
Thus:

$$p = 0.426878 \times V^{-1.13772}$$
$$W = \int_{4.934}^{11.04} 0.426878 \times V^{-1.13772} \mathrm{d}V$$
$$\boxed{= 0.261199 \text{ Btu/lb}}$$

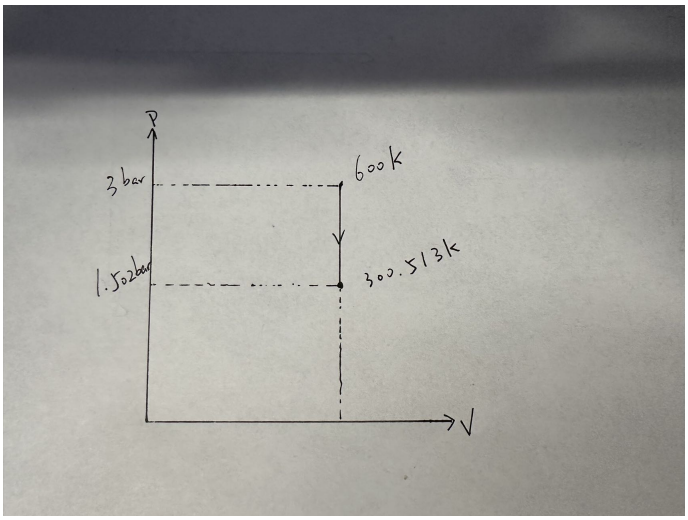
$(1124.2 - 1136.2) + 0.261199 = \boxed{-11.7388 \text{ Btu/lb}}$

3. $0.434 \times 6.22 = \boxed{2.69948\text{kW}}$, $0.434 \times 24 \times 0.1 = \boxed{1.0416\$}$

4. $W = \int p \, \mathrm{d}V = 4 \times (0.6872 - 0.0581) \times 10^5 = \boxed{4.248 \text{ kJ/kg}}$
   $u = 245.73 - 224.24 - 2.248 = \boxed{19.242 \text{ kJ/kg}}$



5. $F_g = mg = 50 \times 9.81 = 490$ N
   $P_p = F_g/A = 490/9.75 \times (10^-3) = 50256.4$ Pa $= 0.502564$ bar
   $\frac{T_1}{T_2} = \frac{P_1}{P_2} = \frac{3}{1.502564}$, Thus, $T_2 = 300.513$ K
   $c_v \approx \frac{0.764+0.718}{2} = 0.741$ kJ/kg·K, $\Delta T = 300.513 - 600 = -299.487$ K
   $\Delta u = \Delta T \times c_v = -299.487 \times 0.741 = -221.92$ kJ/kg
   $\Delta u_{air} = \Delta u \times m = -221.92 \times 0.005 = \boxed{-1.1096 \text{ kJ}}$



6.

$$\varepsilon A \sigma T^4 = E$$

$$T = \left(\frac{E}{2 \times \varepsilon \pi r^2 \sigma}\right)^{1/4}$$

$$T = \left(\frac{150}{4 \times 0.8 \times \pi \times 0.25 \times 5.670373 \times 10^{-8}}\right)^{1/4}$$

$$T = \boxed{254.727 \text{ K}}$$

7. $W = 2 \times 36\% = \boxed{0.72 \text{ MW}}$, $0.72 \times 4380 = \boxed{3153.6 \text{ MW/h}}$,
   $3.1536 \times 10^6 \times 0.08 = \boxed{252288 \$}$