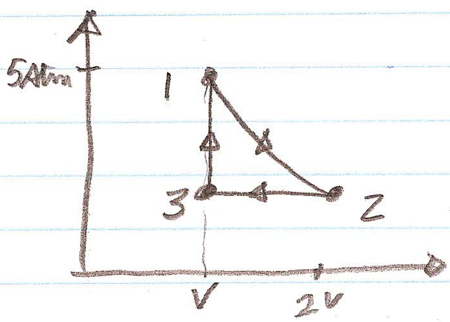
Sample Test Solution.

1.

(a)



(b) 3 translational and 2 rotational

(c) $U = \frac{f}{2} nRT$

$= \frac{5}{2} \times 2 \times 8.314 \times 298$

$= \underline{\underline{12.4\,kJ}}$

(d) $PV = nRT$

$V_1 = \frac{nRT}{P} = \frac{2 \times 8.314 \times 298}{5 \times 1.01 \times 10^5} = 10 \times 10^{-3}\,m^3$

(e) $P_1 V_1^{\gamma} = P_2 V_2^{\gamma} \Rightarrow P_2 = P_1 \left(\frac{V_1}{V_2}\right)^{\gamma} = 5\,atm \left(\frac{V_1}{2V_1}\right)^{1.4}$

$\gamma = \frac{C_P}{C_V} = \frac{\frac{7}{2}R}{\frac{5}{2}R} = 1.4$

$= 1.89\,atm$

$= 1.91 \times 10^5\,Pa.$

(f) $T_3 = \frac{P_3 V_3}{nR} = \frac{1.01 \times 10^5 \times 10 \times 10^{-3}}{2 \times 8.314} = 60K$

(g) $W = P\Delta V = P_2 \times (2V_1 - V_1) = 1.91 \times 10^5\,Pa \times 10 \times 10^{-3}\,m^3$

$= +1914\ J$

(h) 1–2 Adiabatic $\Rightarrow \Delta Q = 0 \Rightarrow \Delta U = \Delta W$

$\Delta U_{12} = U_2 - U_1$

$= \frac{5}{2} nRT_2 - 12.4\,kJ$

$= 4955\,J - 12.4\,kJ$

$= \underline{-7445\ J}$

$\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$

$T_2 = \frac{P_2 V_2}{P_1 V_1} T_1$

$T_2 = \frac{1 \times 2}{5 \times 1} T_1 = 119.2$

2. $\Delta L = 3.000\text{cm} - 3.002\text{cm} = -0.002 \text{ cm}$

$\Delta L = \alpha L \Delta T = 22.2\times10^{-6}/K \times 3.002 \times \Delta T$

(a) $T_f - T_i = \dfrac{\Delta L}{22.2\times10^{-6}\times 3.002} \Rightarrow T_f = \underline{\underline{-5^\circ C}}$

(b) $\Delta V = V_0 \beta \Delta T = \pi r^2 l \, 3\alpha(-5)$

$= \pi(1.5001)^2 \times 6 \times 3 \times 22.2\times10^{-6} \times (-5)$

$= \underline{\underline{-0.014 \text{ cm}^3}}$

3. ΔQ_{water} = heat lost from water to get from 97°C to 79°C.

$= m_w c_w (79-97)$

$= 0.12 \times 4186 \times -18$

$= -9042 \text{ J}.$

$\Delta Q_{ice\ cube}$ = heat required to get one ice cube up to 79°C

$= m_{ice} c_{ice} (0 - {}^-12) + m_w c_w (79-0) + m_i L$

$= 0.002 \times 2050 \times 12 + 0.002 \times 4186 \times 79 + 0.002 \times 334\times10^3$

$= (49.2 + 661.4 + 668) \text{J} = 1379 \text{J}$

$\Rightarrow$ # ice cubes $= \dfrac{9042}{1379} = 6.6$ ie 7 cubes to get below 79°C.

4. $68°F \rightarrow 20°C \quad 28°F \rightarrow -2.2°C$

$P = \dfrac{kA(T_H - T_L)}{L} = \dfrac{1.05 \text{W} \times 9.5\text{m}^2 \times (20 - {}^-2.2)}{8.5\times10^{-3}}$

$= 26.1 \text{ kJ}$

5. (a) $e = 1 - \frac{T_L}{T_H} = 1 - \frac{300K}{600K} = 0.5$

(b) $e = \frac{W_{out}}{Q_{in}} \Rightarrow Q_{in} = \frac{W_{out}}{e} = \frac{120W}{0.5} = \underline{\underline{240W}}$

(c) leg 1 $T_H = 600K$ $Q_{in} = 240W$

$$S_1 = \int \frac{dQ}{T} = \frac{1}{T_H} \int_{ab} dQ = \frac{Q_{in}}{T_H} = \frac{240J}{600} = 0.4$$

S_2 $b \to c$ adiabatic $\Delta Q = 0 \Rightarrow \Delta S = 0$

$$S_3 = \int \frac{dQ}{T} = \frac{1}{T_L} \int_{cd} dQ = \frac{Q_{out}}{300} = \frac{Q_{in} - W}{300}$$

$$= \frac{-120}{300} = -0.4$$

$\Delta S_{TOTAL} = 0$.

– Note: Real test will have similar problems but with a few more parts. ie the real test will be longer than this sample test.

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