1a) $W = P\Delta V$

$= 1.0\times10^6 (0.3)(0.30661 - 0.23275)$

$= 22158\,J$

$\approx 22.16\,kJ$

b) Constant pressure process until the piston hits the stop, so $W = P\Delta V$

Once the piston hits the stop, it is a constant volume process, so $W = 0$

$\therefore W = -1\times10^6 (0.3)(0.4(0.30661))$

$= -36793.2\,J$

$\approx -36.79\,kJ$

The compression work is 36.79kJ.

c) $v_{final} = 0.6(0.30661)$

$= 0.183966\ m^3/kg$

The final temperature is 151.83°C.

2) $W = 2.4\left(\frac{8.3144}{28.97}\right)(273.15+12)\ln\left(\frac{150}{600}\right)$

$= -272.2842329$

$\approx -272\,kJ$

The work input is 272kJ on the system.

3a) Initial $P = P_{atm} + P_{piston}$

$= 95\times10^3 + \frac{150}{50\times10^{-4}}$

$= 125\,kPa$

Initial temperature $= 105.97°C$

$v = v_f + x(v_g - v_f)$

$= 0.001048 + 0.2(1.3750 - 0.001048)$

$= 0.2758384$

Total mass $= \frac{2.5\times10^{-3}}{0.2758384}$

$= 9.063277629\times10^{-3}\,kg$

$\approx 9.063\times10^{-3}\,kg$

3b) Volume increase $= 0.2 \times 50 \times 10^{-4}$

$= 0.001 \, m^3$

$$v = \frac{2.5 \times 10^{-3} + 0.001}{9.063 \times 10^{-3}}$$

$= 0.38612 \, m^3/kg$

$$v = v_f + x(v_g - v_f)$$

$$0.38612 = 0.001048 + x(1.3750 - 0.001048)$$

$x = 0.2802659773$

≈ 0.28

c) Increase in $P = 500 - 125$

$= 375 \, kPa$

$$F = kx$$

$$x = \frac{375 \times 50 \times 10^{-4} \times 10^3}{7.5 \times 10^3}$$

$= 0.25 \, m$

$W = W_{gas} + W_{spring}$

$$= 125 \times 10^3 \times 0.001 + \frac{125 + 500}{2} \times 10^3 (0.25 \times 50 \times 10^{-4})$$

$$= \frac{4125}{8} \, J$$

$\approx 0.5156 \, kJ$

3d) $Q - W = m\Delta u$

$$u_1 = u_f + x u_{fg}$$

$$= 444.23 + 0.2(2068.8)$$

$$= 858.01 \text{ kJ/kg}$$

$$v_2 = \frac{2.5\times10^{-3} + 0.001 + 0.25\times50\times10^{-4}}{9.063\times10^{-3}}$$

$$= 0.52409296 \text{ m}^3/\text{kg}$$

$$\frac{0.52409296 - 0.52261}{0.57015 - 0.52261} = \frac{u_2 - 2803.3}{2883.0 - 2803.3}$$

$$u_2 = 2805.786157 \text{ kJ/kg}$$

$$Q - W = m(u_2 - u_1)$$

$$Q - 0.5156 = 9.063\times10^{-3}(2805.786157 - 858.01)$$

$$Q = 18.16883607$$

$$\approx 18.17 \text{ kJ}$$

3e)