Homework 2 Key

1) a) $m = 1.8\,kg$

$dr = 10\,m$

$dw = -F_{app}\,dr = -mg\,dr = -(1.8\,kg)(9.81\,m/s^2)(10\,m)$

$\boxed{dw = -177\,J}$

b) $P_{ext} = 1.0\,atm$

$V_i = 1.0\,L$

$V_f = 1.9\,L$

$T = 25°C = 298\,K$

$w = -P_{ext}\Delta V = -P_{ext}(V_f - V_i)$

$w = -(1.0\,atm)(1.9\,L - 1.0\,L)$

$w = -0.9\,L\,atm\left(101325\,Pa/atm\right)\left(\frac{1\,m^3}{1000\,L}\right)$

$\boxed{w = -91\,J}$

c) $w = -\int_{V_i}^{V_f} P\,dV$

$P = \frac{nRT}{V - nb} - a\left(\frac{n}{V}\right)^2$

$w = -\int_{V_i}^{V_f}\left(\frac{RT}{V_m - b}\right)dV_m + a\int_{V_i}^{V_f}\left(\frac{dV_m}{V_m^2}\right)$

$w = -RT\ln\left(\frac{V_{mf} - b}{V_{mi} - b}\right) + -a\left(\frac{1}{V_{mf}} - \frac{1}{V_{mi}}\right)$

assume 1 mol: $\frac{V}{n} = V_m$

$w = -(8.2\times10^{-2}\,\frac{L\,atm}{mol\,K})(298\,K)\ln\left(\frac{1.0\,L/mol - 3.05\times10^{-2}\,L^2/mol^2}{1.9\,L/mol - 3.05\times10^{-2}\,L^2/mol^2}\right) - (5.5\,\frac{atm\,L^2}{mol^2})\left(\frac{1}{1.0\,L/mol} - \frac{1}{10\,L/mol}\right)$

$w = 13.4\,L\,atm/mol\left(\frac{101325\,Pa}{1\,atm}\right)\left(\frac{1\,m^3}{1000\,L}\right)$

$\boxed{w = 1350\,J/mol}$

2) a) $\Delta V = 0$ $\quad w = -P_{ext}\Delta V = 0$

$\Delta T > 0$ $\quad q = nC_v\Delta T > 0$

$\Delta P > 0$ $\quad \Delta U = q + w > 0$

b) $\Delta V = 0$

$\Delta T < 0$ $\quad w = -P_{ext}\Delta V = 0$

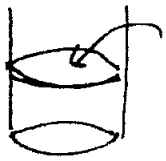
$\Delta P < 0$ $\quad q = nC_v\Delta T < 0$

$\Delta U = q + w < 0$

c) $w_{TOT} = w_a + w_b = 0$

$q_{TOT} = q_A + q_B = 0$

$\Delta U_{TOT} = \Delta U_a + \Delta U_b = 0$

3) 

$A = 1m^2$

$\Delta r = 500\,cm = 5m$

$P_{ext} = 1.0\,atm$

$\Delta V = A\Delta r = (1m^2)(5m) = 5m^3$

$w = -P_{ext}\Delta V = -(1.0\,atm)(5m^3)$

$w = -5\,atm\,m^3\left(\frac{101325\,Pa}{atm}\right) = -5.05\times10^5\,Pa\,m^3$

$\boxed{w = -5.05\times10^5\,J}$

4) a. rigid walls $\Rightarrow \Delta V = 0 \Rightarrow$ $\boxed{w = 0}$

$\Delta T > 0 \Rightarrow \boxed{\Delta U > 0,\ \Delta H > 0}$

$q = \Delta U - w \Rightarrow \boxed{q > 0}$

b. constant ext. pressure $\Rightarrow \Delta P = 0$

$\Delta V < 0 \Rightarrow \boxed{w > 0}$

$\Delta T > 0 \Rightarrow \boxed{\Delta U > 0,\ \Delta H > 0}$

$q = \Delta U - w \Rightarrow \boxed{q > 0}$

c. water heated $\Rightarrow \Delta T > 0$

open beaker in lab $\Rightarrow \Delta P = 0$

liquid $\rightarrow$ hot liquid, $\Delta V = 0$

$\boxed{\begin{aligned} w &= -P\Delta V = 0 \\ \Delta H &= nC_p\Delta T > 0 \\ \Delta U &= \Delta H - P\Delta V > 0 \\ q &= \Delta U - w > 0 \end{aligned}}$

d. performed 100 J of elect. work $\Rightarrow \boxed{w < 0}$ <u>not</u> PV work

released 25 J of heat $\Rightarrow \boxed{q < 0}$

$\boxed{\begin{aligned} \Delta U &= q + w < 0 \\ \Delta H &= \Delta U + \Delta(PV) < 0 \end{aligned}}$ no PV work