

Homework 2 Key

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1) a) $m = 1.8 \text{ kg}$
 $dr = 10 \text{ m}$

$$dw = -F_{\text{app}} dr = -mg dr = -(1.8 \text{ kg})(9.8 \text{ m/s}^2)(10 \text{ m})$$

$$dw = -177 \text{ J}$$

b) $P_{\text{ext}} = 1.0 \text{ atm}$
 $V_i = 1.0 \text{ L}$
 $V_f = 1.9 \text{ L}$
 $T = 25^\circ\text{C} = 298 \text{ K}$

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

$$W = -(1.0 \text{ atm})(1.9 \text{ L} - 1.0 \text{ L})$$

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

$$W = -91 \text{ J}$$

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

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

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

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

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

$$W = - \left(8.314 \text{ J/mol} \cdot \text{K} \right) (298 \text{ K}) \ln \left(\frac{1.0 \text{ L/mol} - 3.65 \times 10^{-2} \text{ L}^2/\text{mol}^2}{1.9 \text{ L/mol} - 3.05 \times 10^{-2} \text{ L}^2/\text{mol}^2} \right) - \left(5.5 \frac{\text{atm} \cdot \text{L}^2}{\text{mol}^2} \right) \left(\frac{1}{1.0 \text{ L/mol}} - \frac{1}{1.9 \text{ L/mol}} \right)$$

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

$$W = 1350 \text{ J/mol}$$

2)

a) $\Delta V = 0$
 $\Delta T > 0$
 $\Delta P > 0$

$W = P_{ext} \Delta V = 0$
 $q = n C_v \Delta T > 0$
 $\Delta U = q + w > 0$

b) $\Delta V = 0$
 $\Delta T < 0$
 $\Delta P < 0$

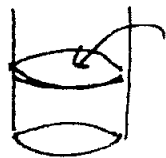
$W = -P_{ext} \Delta V = 0$
 $q = n C_v \Delta T < 0$
 $\Delta U = q + w < 0$

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)



$A = 1m^2$
 $\Delta r = 500cm = 5m$
 $P_{ext} = 1.0atm$

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

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

$W = -5atm m^3 \left(\frac{101325 Pa}{atm} \right) = -5.05 \times 10^5 Pa m^3$

$W = -5.05 \times 10^5 J$

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

$$\Delta T > 0 \Rightarrow \Delta U > 0, \Delta H > 0$$

$$q = \Delta U - w \Rightarrow q > 0$$

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

$$\Delta V < 0 \Rightarrow w > 0$$

$$\Delta T > 0 \Rightarrow \Delta U > 0, \Delta H > 0$$

$$q = \Delta U - w \Rightarrow q > 0$$

c. water heated $\Rightarrow \Delta T > 0$
open beaker in lab $\Rightarrow \Delta P = 0$
liquid \rightarrow hot liquid, $\Delta V = 0$

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

d. performed 100 J of elect. work $\Rightarrow w < 0$ not PV work
released 25 J of heat $\Rightarrow q < 0$

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