CH301H Fall 2011

HW15 key

1. $w = -P_{ext}\Delta V$

$P_{ext} = 50.0$ atm

$V_i = 540$ L

$V_f = 975$ L

$w = -(50.0\text{ atm})(975\text{L} - 540\text{L})$

$w = -2.18\times10^4 \text{ atm L}\left(\frac{1.01\times10^5 \text{ Pa}}{\text{atm}}\right)\left(\frac{1\text{ dm}^3}{1\text{ L}}\right)\left(\frac{\text{m}}{10\text{ dm}}\right)^3$

$w = -2.20\times10^4$ J

2. a) $m = 1.8$ kg

$\Delta r = 10$ m

$w = -F\Delta r$ $F = mg$

$w = -(1.8\text{ kg})(9.81\text{ m/s}^2)(10\text{ m})$

$w = -177 \frac{\text{kg m}^2}{\text{s}^2} = -177$ J

b) $P_{ext} = 1.0$ atm

$V_i = 1.0$ L

$V_f = 1.9$ L

$T = 292$ K (but doesn't matter for this problem)

$w = -P_{ext}\Delta V = -(1.0\text{ atm})(1.9\text{L} - 1.0\text{L})$

$w = -0.9 \text{ L atm} = -91.1$ J

3. $q_p = 4\ kJ/kg\,h$

$m = 65\ kg$

$C_{p,m}(H_2O) = 75.29\ J/K\,mol = 0.07529\ kJ/mol\,K$

assume body is 100% H_2O: $FW(H_2O) = 18\ g/mol = 0.0180\ kg/mol$

$$n = \frac{65\ kg}{0.018\ kg/mol} = \underline{\underline{3608\,mol}}$$

$\Delta H = q_p = n C_{p,m} \Delta T$ (no change in volume)

$$\Delta T = \frac{q_p}{n C_{p,m}} = \frac{4\ kJ/kg\,h}{(3608\ mol)(0.07529\ kJ/mol\,K)}$$

$\underline{\Delta T = 0.0147\ K/kg\,h}$

so 65 kg heats up w/ rate $(0.0147\ K/kg\,h)(65\,kg) = \boxed{0.96\ K/h}$

you probably don't want to work under these conditions for more than 1 hr.

4. 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) $\Delta V = 0$ $\quad w = -P_{ext}\Delta V = 0$

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

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

c) $w_{TOT} = w_A + w_B = 0 + 0$

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

$\Delta U_{TOT} = \Delta U_A + \Delta U_B = 0$

5. $n = 0.500\,mol$

$FW(N_2) = 28\,g/mol$

$P_i = 1.0\,atm$ $\quad P_f = 0.200\,atm$

$T_i = 273\,K$ $\quad T_f = 210\,K$

$P_{ext} = 0.100\,atm$

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

$$V_f = \frac{nRT_f}{P_f} \;;\; V_i = \frac{nRT_i}{P_i}$$

$$w = -P_{ext}\left(\frac{nRT_f}{P_f} - \frac{nRT_i}{P_i}\right)$$

$$= -P_{ext}nR\left(\frac{T_f}{P_f} - \frac{T_i}{P_i}\right)$$

$$w = -(0.100\,atm)(0.50\,mol)(8.31\,J/K\,mol)\left(\frac{210\,K}{0.20\,atm} - \frac{273\,K}{1.0\,atm}\right)$$

$$\boxed{w = -322\,J}$$

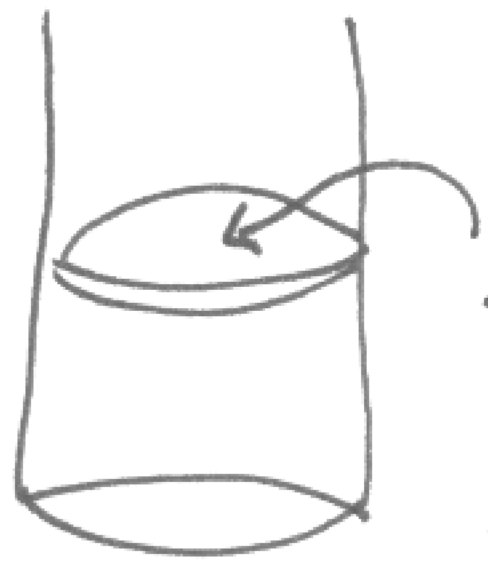
cont. $\Delta U = n C_v \Delta T = n\left(\frac{3}{2}\right) R \Delta T = (0.50 mol)(3/2)(8.31 J/K mol)(210K - 273K)$

$\Delta U = -393 J$

$\Delta U = q + w$

$q = \Delta U - w = -70 J$

6.



$A = 1 m^2$

$\Delta r = 500 cm = 5 m$

$P_{ext} = 1.0 atm$

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

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

$w = -5 atm m^3 \left(\frac{1.01 \times 10^5 Pa}{1 atm}\right) =$

$w = -5.05 \times 10^5 Pa m^3 = -5.05 \times 10^5 J$

7. $\Delta H_{com} = -2091 kJ/mol$

$\Delta H_f\, CO_2(g) = -393.51 kJ/mol$

$\Delta H_f\, (H_2O(l)) = -285.83 kJ/mol$

combustion: $C_3H_6(g) + \frac{9}{2} O_2 \longrightarrow 3 CO_2(g) + 3 H_2O(l)$ $\Delta H_{com} = -2091 kJ/mol$

$\Delta H_f (C_3H_6) = \Delta H_{com} + 3 \Delta H_f (CO_2) + 3 \Delta H_f (H_2O)$

$\Delta H_f (C_3H_6) = 53 kJ/mol$

Isomerization:

C_3H_6 (cyclo) ⇌ C_3H_6 (propene)

$\Delta H_{rxn} = \Delta H_f$ (propene) $- \Delta H_f$ (cyclo)

$= 20.4\ kJ/mol - 53\ kJ/mol$

$\Delta H_{rxn} = -33\ kJ/mol$

This large release in energy represents the strain energy wrapped up in keeping the C-C bond angles at 60°.