1) $8.314\ J/mole \cdot K$

$1 Pa = \frac{J}{m^3}$ $J = m^3 \cdot Pa$ $1 Pa = 10^{-6}\ MPa$

$$\frac{8.314\ m^3 Pa}{mole \cdot K}\left(\frac{1\times10^{6}\ cm^3}{m^3}\right)\left(\frac{MPa}{1\times10^{6}\ Pa}\right) = \frac{8.314\ cm^3 \cdot MPa}{mole \cdot K}$$

$1 cm^3 = 1 mL$

$1 mL = 2.6\times10^{-4}$ gallons

1.0.1 bar = 1 MPa 14.50 bar = 1 PSI

145.0 MPa = 1 psi

$$\frac{8.314\ cm^3 \cdot MPa}{mole \cdot K}\left(\frac{1 mL}{cm^3}\right)\left(\frac{2.6\times10^{-4}\ gal}{mL}\right)\left(\frac{PSI}{145.0\ MPa}\right) = \frac{1.5\times10^{-5}\ gal \cdot PSI}{mole \cdot K}$$

2. A) $\Delta PE = mg\Delta h$

$= (50\,kg)(9.8\,\frac{m}{s^2})(1\,m)$

$= 490\,kg\,\frac{m^2}{s^2}$

$= 490\,J$

B) $C + O_2 \rightarrow CO_2$ 393 KJ/mol

$\frac{1g\ carbon}{12g\ carbon/mole} = .083$ mole ~~carbon~~

393 KJ/mole · .083 mole = 32.750 KJ = 32,750 J

C.) $1840\,Kcal \cdot \frac{1\,J}{0.239\,cal} \cdot \frac{1000\,cal}{1\,Kcal} = 7.70 \times 10^6\,J$

D) $100\,W = 100\frac{J}{Sec} \cdot \frac{60\,Sec}{1\,min} \cdot \frac{60\,min}{1\,hr} \cdot \frac{24\,hr}{1\,day} = 8.64 \times 10^6\,J/DAY$

4. $W = -\int_{V_1}^{V_2} P\,dV$

$= \int_{V_1}^{V_2} \frac{RT}{V_m - b} - \frac{a}{TV^2}\,dV_m$

$= -\left[RT \ln[V_m - b]\Big|_{V_1}^{V_2} + \frac{A}{TV_m}\Big|_{V_1}^{V2}\right]$

$\approx -40.60\,\frac{L \cdot bar}{mol}$

$= -4060\,J/mol$

$R = .08314\,\frac{L \cdot bar}{K \cdot mol}$

$T = 300K$

$a = 10.0\,L^2 \cdot bar\,K/mol^2$

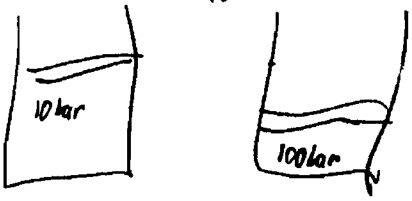
$V_1 = \frac{4L}{22.4\,L/mol}$

$V_2 = \frac{10L}{22.4\,L/mol}$

3) 2 moles

$C_{v,m} = 1.5R$

100 bar



300K

for isothermal process no heat is transferred

$Q = 0$

find ΔU

$P_{ext_I} = 100 bar$

$P_{ext_F} = 10 bar$

$\Delta U = q + W$

Process 1

$$W = -\int_{V_i}^{V_F} P_{ext}\, dV$$

$PV = nRT$

$V_i = \frac{nRT}{P_i}$

$V_f = \frac{nRT}{P_f}$

$$W_1 = -P_F\left(\frac{nRT}{P_F} - \frac{nRT}{P_I}\right)$$

$$W_1 = -nRT + nRT\left(\frac{P_F}{P_I}\right)$$

$$W_1 = -nRT\left(1 - \frac{P_F}{P_I}\right)$$

$n = 2$ $T = 300 K$

$R = 8.314 J/mole \cdot K$

$T = 300 K$

$P_I = 10 bar$

$P_F = 100 bar$

$$W_1 = \frac{-8.314 J \cdot 2 moles \cdot 300K}{mole \cdot K}\left(1 - \frac{100 bar}{10 bar}\right)$$

$\Delta U = q + w$

$\Delta U = 0$

$q = -w$

$W_1 = 44,895.6 J$ $q = -44,895.6 J$

reverse process

W_2

$P_F = 10 bar$ $P_I = 100 bar$

$\Delta U = 0$

$$W_2 = -nRT\left(1 - \frac{P_F}{P_I}\right)$$

$$W_2 = -2 moles \cdot 8.314 J \cdot 300K \left(1 - \frac{10 bar}{\ldots}\right)$$

$W_2 = -4,489.6 J$

$q = 4489.6 J$

$\Delta U = 0$ because it is a property of the system and the initial and final systems are the same

total $W = W_1 + W_2 = 44{,}895.6\,J + (-4489.6\,J) = 40{,}406\,J$

$q_{total} = q_1 + q_2 = -44{,}895.6\,J + 4{,}489.6\,J = -40{,}406\,J$

for reversible expansion
P_{ext} is not a constant

$P_{ext} = \frac{nRT}{V}$

$$W = -\int_{V_i}^{V_f} P_{ext}\,dV = -\int_{V_i}^{V_f} \frac{nRT}{V}\,dV = -nRT\int_{V_i}^{V_f} \frac{dV}{V} = -nRT\ln\left(\frac{V_f}{V_I}\right)$$

$V_f = \frac{nRT}{P_f}$

$V_I = \frac{nRT}{P_I}$

$$\frac{\left(\frac{nRT}{P_f}\right)}{\left(\frac{nRT}{P_I}\right)} = \frac{P_I}{P_f}$$

forward

$$W = -nRT\ln\left(\frac{P_I}{P_f}\right) = -\frac{2\,mole \cdot 8.314\,J \cdot 300\,K}{mole \cdot K}\left(\ln\left(\frac{10\,bar}{100\,bar}\right)\right) = +11{,}486.2\,J$$

$q = -11{,}486.2\,J$

reverse process

$$w = -\frac{2\,mole\ 8.314\,J\ 300\,K}{mole \cdot K}\ln\left(\frac{100}{10}\right) = -11{,}486.2\,J$$

$q = 11{,}486.2\,J$

$W_{TOTAL} = W_{forward} + W_{REVERSE} = 11{,}486.2\,J - 11{,}486.2\,J = 0$

$q_{TOTAL} = q_{forward} + q_{reverse} = -11{,}486.2\,J + 11{,}486.2\,J = 0$

$\Delta U_{total} = 0$

5) $$C_p = C_v + T\left(\frac{\partial P}{\partial T}\right)_V \left(\frac{\partial V}{\partial T}\right)_P$$

C_p & C_v for hard sphere gas that obeys the eq of state

$$P(V-nb) = nRT$$

$$P = \frac{nRT}{(V-nb)} \qquad \left(\frac{\partial P}{\partial T}\right)_V = \frac{nR}{(V-nb)}$$

$$V - nb = \frac{nRT}{P}$$

$$V = \frac{nRT}{P} + nb \qquad \left(\frac{\partial V}{\partial T}\right)_P = \frac{nR}{P} + 0$$

$$C_p = C_v + T\left(\frac{nR}{V-nb}\right)\left(\frac{nR}{P}\right)$$

$$\frac{nRT}{V-nb} = P$$

$$C_p = C_v + P\left(\frac{nR}{P}\right)$$

$$\boxed{C_p = C_v + nR}$$

7) $\Delta_r H^\circ$ 298°K & 600K

$3H_2(g) + N_2(g) \rightarrow 2NH_3(g)$

$\Delta H_f\ H_2 = 0$ $\Delta H_f\ NH_3(g) = -46.11\ kJ/mole$

$\Delta H_f\ N_2 = 0$

$$\Delta_r H^\circ = \sum_{products} a\Delta H_f - \sum_{reactants} a\Delta H_f$$

heat of formation of an element in its std. state is 0

$$\Delta_r H^\circ = 2(-46.11\ kJ/mole) - 3(0) + 0$$

assume C_p is independent of T

$$\Delta_r H^\circ = -92.22\ kJ/mole \quad @\ 298°K$$

$$\Delta_r C_p^\ominus = 2C_{p,m}^\ominus(NH_3) - (3C_{p,m}\ H_2 + C_{p,m}\ N_2)$$

$C_{p,m}(NH_3) = 35.06$, $C_{p,m}\ H_2 = 28.82$, $C_{p,m}\ N_2 = 29.13$

$$\Delta_r C_{p,m}^\ominus = 70.12\ \frac{J}{mole \cdot K} - 86.46\ J/mole \cdot K - 29.13\ J/mole \cdot K$$

$$\Delta_r C_{p,m}^\ominus = -45.47\ J/mole \cdot K$$

$$\Delta_r H^\ominus(600K) = \Delta_r H^\ominus(298°K) + \int_{T_1}^{T_2} \Delta_r C_p^\ominus\, dT$$

$$(-92.22\ kJ/mole) + \Delta_r C_p^\ominus (T_F - T_I) \quad (600 - 298)$$

$$\Delta_r H^\ominus(600) = -\frac{92.22\ kJ \cdot 1000\ J}{mole\ \ kJ} + \frac{-45.47\ J}{mole \cdot K}(302\ K)$$

$$\Delta_r H^\ominus(600) = -\frac{105 \times 10^3\ J}{mole}\left(\frac{kJ}{10^3\ J}\right)$$

$$q = \Delta H = \Delta H^\ominus \times \frac{n}{2} = \frac{\Delta_r H^\ominus \times 200}{2}$$

stoich coefficient for rxn

to form 200 moles HN_3

$$q = \frac{\Delta_r H^\ominus \times 200}{2}$$

$$q = -10,500\ kJ$$

8) $C_{(s)} + O_{2(g)} \rightarrow CO_{2(g)}$ $\Delta H_f = 393$ kJ/mol

$\frac{.2g}{12\, g/mole} = 0.0166$ mol Carbon

$0.0166 \cdot 393$ kJ $= 6.55$ kJ

- In the Container there is 24.9843 mole O_2
  0.0167 mole CO_2

$C_p^{O_2} = 29.355$ J/K/mol $\times 24.9843 = 733.41$ J/K
$C_p^{CO_2} = 37.11$ J/K mol $\times 0.0167 = .62$ J/K
$C_p^{cal} = 2000$ J/K

+ 2000 J/K
2734 J/K

Constant Pressure

$\Delta H \approx \Delta U$ b/c volume of the solid is small

$\Delta U = C_v \Delta T$

$6550 J = 2734 \frac{J}{K} \Delta T$

$\Delta T = 2.396 K$

Constant Volume

$\Delta U = C_v \Delta T$

$6550 J = 2734$ J/K ΔT

$\Delta T = 2.396$