2. $\Delta H_m(78.3°C) = \Delta vap H_m(25°C) + \int_{295k}^{351.3k} \Delta C_p \, dT - 1$

$\Delta C_p = C_{p,prod} - C_{p,react} = C_p^{prod} - C_p^{react}$
$= (65.6 \, J/mak + 2.38 \times 10^{-4} \, t \cdot J/mol/k) - 112 \, J/mol \cdot k$
$= 46.4 \, J/mol k + 2.38 \times 10^4 \, J \cdot T/mol/k$

$\int_{298k}^{351.3k} C_p \, dT = \int_{295k}^{351.3k} (-46.4 \, J/mol k + 2.38 \, t \cdot J/mol/k) \, dT$

$= -46.4 \, [T] \Big|_{295k}^{351.3k} + \frac{2.38 \times 10^{-4}}{2} [T^2] \Big|_{298k}^{351.3k}$

$= -46.4 (351.3 - 298) + 1.19 \times 10^{-4} (351.3^2 - 298^2)$

$= -2.469 \, kJ/mol$

$\boxed{\Delta H_m = -2.469 \, kJ/mol}$

$\Delta vap H_m(78.3°C) = \Delta vap H_m(25°C) + \int_{298k}^{351.3k} C_p \, dT$
$= 42.2 \, kJ/mol - 2.469 \, kJ/mol$

$\boxed{\Delta vap H_m = 39.831 \, kJ/mol}$

$\Delta vap S_m(78.3°C) = \frac{\Delta vap H_m(78.3°C)}{T_B \ln(k)} = \frac{39.831 \, kJ/mol}{351.3 k}$

$\boxed{\Delta vap S_m = 113.38 \, J/mol k}$

Graph problem

$\Delta H = T \Delta S$ $\qquad \Delta S_{70k \to 150k} = \frac{(\Delta H_2)}{T_2} - \frac{(\Delta H_1)}{T_1}$

$\frac{44500}{54.34} - \frac{6815.0}{90.26} = 6.26 \, J/k$

$\boxed{\Delta S_{70k \to 150k} = 6.26 \, J/k}$

∴ the process is spontaneous

3. (a) $dS = \left(\frac{\partial S}{\partial P}\right)_T dP + \left(\frac{\partial S}{\partial T}\right) dT$

$\left(\frac{\partial S}{\partial P}\right)_P = \frac{C_P}{T}$ and $\left(\frac{\partial S}{\partial T}\right)_P = \frac{1}{T}\left[\left(\frac{\partial H}{\partial P}\right)_T - V\right]$

Maxwell: $\left(\frac{\partial S}{\partial P}\right)_T = -\left(\frac{\partial V}{\partial T}\right)_P = -V\beta$

$dS = \frac{C_P}{T} dT - V\beta dP$

(b) $dS = \frac{C_P}{T} dT - V\beta dP$

$\Delta S = \int_{T_i}^{T_f} \frac{C_P}{T} dT - \int_{P_i}^{P_f} V\beta dP$

Numerical problems

1. $\Delta H^\circ_{rxn} = \Sigma \Delta H^\circ_{F,\,prod} - \Sigma H^\circ_{F,\,react}$
$= (-1364 - 278 - 394) - (-1273)$ kJ/mol
$\boxed{= -763 \text{ kJ/mol}}$

$\Delta S^\circ_{rxn} = \Sigma S^\circ_{prod} - \Sigma S^\circ_{react}$
$= (192 + 161 + 213) - (209)$ J/mol K
$\boxed{= 357 \text{ J/mol K}}$

$\Delta S_{surr} = -\frac{\Delta H_{rxn}}{T} = -\frac{(-763 \text{ kJ/mol})}{298 \text{ K}} = \boxed{2.56 \times 10^3 \frac{J}{mol \cdot K}}$

$\Delta S_{univ} = \Delta S_{rxn} + \Delta S_{surr} = 357 \frac{J}{mol\,K} + 2.56 \times 10^3 \frac{J}{mol\,K}$
$= 2917 \text{ J/mol K}$

The reaction is spontaneous because $\Delta S_{univ} > 0$

Problem Set 4   Kylee McDonald

Analytical problems

1. Reversible: entropy transfers through heat interactions

$$\Delta S = \frac{d\,q_{reversible}}{T}$$

adiabatic: no heat enters or leaves the system

so $\boxed{q = 0}$

thus, for a reversible adiabatic process: $\boxed{\Delta S = 0}$

2. (a) $\Delta U = 0$
$\Delta H = 0$ } all three are state functions and in a cyclic process
$\Delta S = 0$ initial and final states are the same. Thus, all state functions are 0

(b) $a \to b$ $T = constant.$ $\Delta U = 0$
$b \to c$ and $d \to a$ adiabatic: $q = 0$

$W = -nRT_h \ln \left(\frac{V_b}{V_a}\right)$ $\Delta U = q$
                                            $W = 0$

$\Rightarrow q = -W = -nRT_h \ln \left(\frac{V_b}{V_a}\right) \Rightarrow \boxed{q = nRT_h \ln \left(\frac{V_b}{V_a}\right)}$

from $\underline{a \to b}$ heat is $\underline{absorbed}$

(c) $W_{tot} = W_{ab} + W_{cd} + W_{da} \overset{0}{+ W_{bc}} \overset{0}{}$

$W_{tot} = -nRT_h \ln \left(\frac{V_b}{V_a}\right) - nRT_l \ln \left(\frac{V_a}{V_b}\right)$

$W_{tot} = -(T_h - T_l) nR \ln \left(\frac{V_b}{V_a}\right)$

Total work is negative

(d) efficiency $(\varepsilon) = \dfrac{\text{net work done by heat engine}}{\text{heat absorbed by heat engine}}$

$\varepsilon = \dfrac{-W}{q} = \dfrac{-[-(T_h - T_c) nRT \ln \left(\frac{V_b}{V_a}\right)]}{nRT_h \ln (V_b/V_a)}$

$\Rightarrow \boxed{\varepsilon = \dfrac{T_h - T_c}{T_h} = 1 - \dfrac{T_c}{T_h}}$