CHE 203

HW # 3

8.2 a. $C_v = C_p - R \Rightarrow C_v = (35.3 + 0.0291T)[J/(\text{mol}\cdot°C)] - (8.314\ [J/(\text{mol}\cdot K)])(1\ K/1°C)$

$\Rightarrow \underline{C_v = 27.0 + 0.0291T\ [J/(\text{mol}\cdot°C)]}$

b. $\Delta\hat{H} = \int_{25}^{100} C_p\,dT = 35.3T\Big]_{25}^{100} + 0.0291\dfrac{T^2}{2}\Big]_{25}^{100} = \underline{2784\ \ J/\text{mol}}$

c. $\Delta\hat{U} = \int_{25}^{100} C_v\,dT = \int_{25}^{100} C_p\,dT - \int_{25}^{100} R\,dT = \Delta\hat{H} - R\Delta T = 2784 - (8.314)(100-25) = \underline{2160\ \ J/\text{mol}}$

d. $\underline{\hat{H}\text{ is a state property}}$

8.5 $H_2O\ (v,\ 100°C,\ 1\ \text{atm}) \rightarrow H_2O\ (v,\ 350°C,\ 100\ \text{bar})$

a. $\hat{H} = 2926\ \ kJ/kg - 2676\ \ kJ/kg = \underline{250\ \ kJ/kg}$

b. $\hat{H} = \int_{100}^{350}\left[0.03346 - 0.6886\times10^{-5}T + 0.7604\times10^{-8}T^2 - 3.593\times10^{-12}T^3\right]dT$

$= 8.845\ \ kJ/\text{mol} \Rightarrow \underline{491.4\ \ kJ/kg}$

Difference results from assumption in (b) that $\hat{H}$ is independent of P. The numerical difference is $\Delta\hat{H}$ for $H_2O(v,\ 350°C,\ 1\ \text{atm}) \rightarrow H_2O(v,\ 350°C,\ 100\ \text{bar})$

8.9 a.

$$Q = \Delta H = (5{,}000\ \ \text{mol/s})\cdot\overbrace{\int_{100}^{200}\left[0.03360 - 1.367\times10^{-5}T - 1.607\times10^{-8}T^2 + 6.473\times10^{-12}T^3\right]dT}^{kJ/mol}$$

$= \underline{17{,}650\ kW}$

b. $Q = \Delta U = \Delta H - \Delta PV = \Delta H - nR\Delta T = 17{,}650\ kJ - (5.0\ \text{kmol})\cdot(8.314\ [kJ/(\text{kmol}\cdot K)])\cdot(100\ K)$

$= \underline{13{,}490\ kJ}$

The difference is the flow work done on the gas in the continuous system.

c. $Q_{additional}$ = heat needed to raise temperature of vessel wall − heat that escapes from wall to surroundings.

8.15 a. $\dot{n} = 250 \text{ mol/h}$

i) $$\dot{Q} = \dot{n}\Delta\hat{H} = \frac{250 \text{ mol}}{\text{h}} \left| \frac{(2676-3697) \text{ kJ}}{1 \text{ kg}} \right| \frac{1 \text{ kg}}{1000 \text{ g}} \left| \frac{1 \text{ h}}{3600 \text{ s}} \right| \frac{18.02 \text{ g}}{1 \text{ mol}} = \underline{-1.278 \text{ kW}}$$

ii) $$\dot{Q} = \dot{n}\Delta\hat{H} = \dot{n} \cdot \int_{T_1}^{T_2} C_p dT$$

$$= \frac{250 \text{ mol}}{\text{h}} \left| \frac{1 \text{ h}}{3600 \text{ s}} \int_{600}^{100} [0.03346 + 0.6880 \times 10^{-5} T + 0.7604 \times 10^{-8} T^2 - 3.593 \times 10^{-12} T^3] = \underline{-1.274 \text{ kW}} \right.$$

iii) $$\dot{Q} = \frac{250 \text{ mol}}{3600 \text{ s}} \cdot (2.54 - 20.91) \text{ [kJ/mol]} = \underline{-1.276 \text{ kW}}$$

b. Method (i) is most accurate since it is not based on ideal gas assumption.

c. The work done by the water vapor.

8.23 Assume $\Delta H_{mix} \cong 0 \Rightarrow \Delta H = \Delta H_{C_{10}H_{12}O_2} + \Delta H_{C_6H_6}$

<u>Kopp's rule</u>: $(C_p)_{C_{10}H_{12}O_2} = 10(12) + 12(18) + 2(25) = 386 \text{ J/(mol} \cdot {}^\circ\text{C)} = 2.35 \text{ J/(g} \cdot {}^\circ\text{C)}$

$$\Delta H_{C_{10}H_{12}O_2} = \frac{20.0 \text{ L}}{} \left| \frac{1021 \text{ g}}{\text{L}} \right| \frac{1 \text{ kJ}}{10^3 \text{ J}} \left| \frac{2.35 \text{ J}}{\text{g} \cdot {}^\circ\text{C}} \right| \frac{(71-25) \ {}^\circ\text{C}}{} = 2207 \text{ kJ}$$

$$\Delta H_{C_6H_6} = \frac{15.0 \text{ L}}{} \left| \frac{879 \text{ g}}{\text{L}} \right| \frac{1 \text{ mol}}{78.11 \text{ g}} \cdot \left[\int_{298}^{348} [0.06255 + 23.4 \times 10^{-5} \text{T}] \, \text{dT} \right] = 1166 \text{ kJ}$$

$\Delta H = 2207 + 1166 = \underline{3373 \text{ kJ}}$

8.43 $\underline{C_7H_{12}N}$: <u>Kopp's Rule</u> $\Rightarrow C_p = 7(0.012) + 12(0.018) + 0.033 = 0.333 \text{ kJ/(mol} \cdot {}^\circ\text{C)}$

<u>Trouton's Rule</u> $\Rightarrow \Delta\hat{H}_v(200^\circ \text{C}) = 0.088(200 + 273.2) = 41.6 \text{ kJ/mol}$

$$C_7H_{12}N(l, 25^\circ \text{C}) \rightarrow C_7H_{12}N(l, 200^\circ \text{C}) \rightarrow C_7H_{12}N(v, 200^\circ \text{C})$$

$$\Delta\hat{H} = \int_{25}^{200} C_p dT + \Delta\hat{H}_v(200^\circ \text{C}) = 0.333(200-25) \frac{\text{kJ}}{\text{mol}} + 41.6 \frac{\text{kJ}}{\text{mol}} = \underline{100 \text{ kJ/mol}}$$