Chemistry 2720 Fall 2003 Quiz 2 Solution

It's easier to see what we're trying to do if we draw a diagram:

$$\begin{array}{ccc} \mathrm{C_6H_{6(g)}} + 3\mathrm{H_{2(g)}} \text{ at } 550\,\mathrm{K} & \xrightarrow{\Delta\bar{H}} & \mathrm{C_6H_{12(g)}} \text{ at } 1290\,\mathrm{K} \\ \Big\downarrow 1 & & \Big\uparrow 3 \\ \mathrm{C_6H_{6(g)}} + 3\mathrm{H_{2(g)}} \text{ at } 298.15\,\mathrm{K} & \xrightarrow{2} & \mathrm{C_6H_{12(g)}} \text{ at } 298.15\,\mathrm{K} \end{array}$$

We want to take reactants at 550 K and make products at 1290 K. We can't do this calculation directly, so we follow the path $1 \to 2 \to 3$. The required calculations are as follows:

$$\begin{aligned} \Delta\bar{H}_1 &= \left(\bar{C}_{P(\mathrm{C_6H_6})} + 3\bar{C}_{P(\mathrm{H_2})}\right)\Delta T_1 \\ &= \left(82.44 + 3(28.84)\,\mathrm{J\,K^{-1}mol^{-1}}\right)(298.15 - 550\,\mathrm{K}) \\ &= -42.55\,\mathrm{kJ/mol} \\ \Delta\bar{H}_2 &= \Delta\bar{H}^\circ_{f(\mathrm{C_6H_{12}})} - \left(\Delta\bar{H}^\circ_{f(\mathrm{C_6H_6})} + \Delta\bar{H}^\circ_{f(\mathrm{H_2})}\right) \\ &= -123.1 - 82.9\,\mathrm{kJ/mol} = -206.0\,\mathrm{kJ/mol} \\ \Delta\bar{H}_3 &= \bar{C}_{P(\mathrm{C_6H_{12}})}\Delta T_3 \\ &= \left(105.3\,\mathrm{J\,K^{-1}mol^{-1}}\right)(1290 - 298.15\,\mathrm{K}) \\ &= 104.44\,\mathrm{kJ/mol} \\ \therefore \Delta\bar{H} &= \Delta\bar{H}_1 + \Delta\bar{H}_2 + \Delta\bar{H}_3 \\ &= -42.55 + (-206.0) + 104.44\,\mathrm{kJ/mol} = -144.1\,\mathrm{kJ/mol} \end{aligned}$$