Chemistry 2720 Fall 2005 Quiz 2 Solution

The reaction is

$$Pb^{2+}_{(aq)} + CO^{2-}_{3(aq)} \rightarrow PbCO_{3(s)}.$$

For this reaction,

$$\begin{aligned}
\Delta\bar{H}^\circ &= \Delta\bar{H}^\circ_{f(PbCO_3)} - \left(\Delta\bar{H}^\circ_{f(Pb^{2+})} + \Delta\bar{H}^\circ_{f(CO_3^{2-})}\right) \\
&= -699.1 - [0.92 + (-675.23)]\ \text{kJ/mol} = -24.8\,\text{kJ/mol}.
\end{aligned}$$

The lead (II) ion is clearly the limiting reagent: We have a smaller volume of lead acetate solution, and it's less concentrated. The number of moles of lead (II) ion is

$$n_{Pb^{2+}} = (0.200\,\text{L})(0.04\,\text{mol/L}) = 0.008\,\text{mol}.$$

Since lead carbonate is sparingly soluble, we will get almost exactly this number of moles of lead carbonate. The heat generated by the reaction is therefore

$$q_{rxn} = (-24.8\,\text{kJ/mol})(0.008\,\text{mol}) = -198\,\text{J}.$$

We have a total of 700 mL of water, so about 700 g. The heat balance is

$$q = 0 = q_{rxn} + q_{H_2O},$$

from which we have, finally,

$$\begin{aligned}
q_{H_2O} &= m_{H_2O}\tilde{C}_{P(H_2O)}\Delta T = -q_{rxn}. \\
\therefore \Delta T &= \frac{-q_{rxn}}{m_{H_2O}\tilde{C}_{P(H_2O)}} = \frac{198\,\text{J}}{(700\,\text{g})(4.184\,\text{J}\,\text{K}^{-1}\text{g}^{-1})} = 0.07\,\text{K}.
\end{aligned}$$

The temperature increases, but only by 0.07°C.