

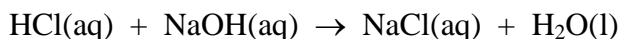
Determination of Enthalpy of Neutralization by Calorimetry

Problem 7-24

The heat of neutralization of HCl(aq) by NaOH(aq) is $-55.84 \text{ kJ/mol H}_2\text{O}$ produced. If 50.00 mL of 1.05 M NaOH is added to 25.00 mL of 1.86 M HCl , with both solutions originally at 24.72°C , what will be the final temperature? Assume that no heat is lost to the surrounding air and that the solution produced in the neutralization reaction has a density of 1.02 g/mL and a specific heat of $3.89 \text{ J g}^{-1}\text{C}^{-1}$.

Solution:

This is a combination of a limiting reactant problem and calorimetry. Let's start with the stoichiometry.



$$n_{\text{HCl}} = 0.02500 \text{ L} \times 1.86 \text{ M} = 0.04650 \text{ mol HCl}$$

$$n_{\text{NaOH}} = 0.05000 \text{ L} \times 1.05 \text{ M} = 0.05250 \text{ mol NaOH}$$

Since the stoichiometry is 1:1, by inspection the HCl is the limiting reactant.

$$n_{\text{H}_2\text{O}} = 0.04650 \text{ mol H}_2\text{O produced}$$

Now for the calorimetry. Write the 1st Law equation for the system:

$$q_{\text{rxn}} + q_{\text{soln}} = 0$$

Expand the heat terms

$$\Delta H_{\text{neutralization}} \times n_{\text{H}_2\text{O}} + m_{\text{soln}} c_{\text{soln}} \Delta T_{\text{soln}} = 0$$

The mass of the solution is calculated from density and volume:

$$m_{\text{soln}} = 75.00 \text{ mL} \times 1.02 \frac{\text{g}}{\text{mL}} = 76.50 \text{ g soln}$$

Finally, do the algebra:

$$\left(-55.84 \times 10^3 \frac{\text{J}}{\text{mol}}\right)(0.04650 \text{ mol H}_2\text{O}) + (76.50 \text{ g})\left(3.89 \frac{\text{J}}{\text{g}^\circ\text{C}}\right)(T_f - 24.72^\circ\text{C}) = 0$$

$$\left(297.59 \frac{\text{J}}{^\circ\text{C}}\right)(T_f - 24.72^\circ\text{C}) = 2596.56 \text{ J}$$

$$(T_f - 24.72^\circ\text{C}) = 8.725^\circ\text{C}$$

$$T_f = 33.45^\circ\text{C}$$