Enthalpy of Diluting Strong Acids Worksheet – Answer Key

The addition of a strong acid to water generates heat; that is, the reaction is exothermic. In this worksheet you will determine the change in temperature when H_2SO_4 is added to water and consider one of its implications.

When adding concentrated sulfuric acid to water the following reaction takes place

$$H_2SO_4(l) \rightarrow H^+(aq) + HSO_4^-(aq)$$

Calculate ΔH for this reaction given that the heats of formation for $H_2SO_4(l)$, $H^+(aq)$, and $HSO_4^-(aq)$ are -813.989 kJ/mol_{rxn}, 0 kJ/mol_{rxn} (defined), and -885.75 kJ/mol_{rxn}, respectively.

$$\Delta H = [\Delta H_{f,HSO_4^-} + \Delta H_{f,H^+}] - [\Delta H_{f,H_2SO_4}] = [(-885.75) + 0] - [(-813.989)]$$

$$\Delta H = -71.76\ kJ/mol_{rxn}$$

Now, suppose you carry out this reaction in a calorimeter by mixing 10.0 mL of concentrated (18.0 M) H_2SO_4 with enough water to give a final volume of 100.0 mL. The density of the resulting solution is 1.08 g/mL and its specific heat is 3.50 $J/g{\cdot}^oC$. If the initial temperature is 25.0^oC, what is the final temperature (assuming a perfect calorimeter that neither absorbs heat nor loses heat to the surroundings)?

To begin, we find q_{rxn}, which, in Joules, is

$$q_{rxn} = (-71.76\ kJ/mol_{rxn}) \times (1\ mol_{rxn}/mol\ H_2SO_4) \times (18.0\ mol\ H_2SO_4/L) \times (0.0100\ L) \times (1000\ J/kJ) = -12916.8\ J$$

Then, using the relationship for q_{soln}, we calculate the final temperature

$$q_{soln} = -q_{rxn} = +12916.8\ J = mS\Delta T = mS(T_{final} - T_{initial}) =$$

$$(100.0\ mL) \times (1.08\ g/mL) \times (3.50\ J/g{\cdot}^oC) \times (T_{final} - 25.0^oC)$$

$$T_{final} - 25.0^oC = 34.17^oC \text{ and } T_{final} = 59.2^oC$$

Based on the result of your calculations, speculate on why instructions for preparing dilute solutions of strong acids always emphasize that the strong acid should be added to water instead of adding water to the strong acid.

The dissolution of a strong acid in water is strongly exothermic. To prevent the resulting system from overheating, the energy needs to be dissipated into a large volume. Adding the acid to a large volume of water accomplishes this. If we were to add the water to a strong acid, the dissolution of the acid into a small portion of that water would potentially lead to a large change in temperature that might cause the water to boil and splashing from the container, creating a safety hazard.