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 $\Delta H°$ for this reaction given that the standard state 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.

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

$$\Delta H° = -71.76 \text{ kJ/mol}_{rxn}$$

Now, suppose you carry out this reaction in a calorimeter by mixing 10.0 mL of concentrated (18.0 M) H_2SO_4 with sufficient 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•°C. If the initial temperature is 25.0°C, what is the mixture's final temperature (you may assume a perfect calorimeter that neither absorbs heat nor loses heat to the surroundings)?

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

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

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

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

$$(100.0 \text{ mL}) \times (1.08 \text{ g/mL}) \times (3.50 \text{ J/g•°C}) \times (T_{final} - 25.0°C)$$

$$T_{final} - 25.0°C = 34.17°C$$

$$T_{final} = 59.2°C$$

Based on the result of your calculations, speculate on why instructions for preparing dilute solutions of strong acids always emphasize that one should a strong acid 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, we need to dissipate the energy into a large volume. Adding acid to a large volume of water accomplishes this. If we add water to a strong acid, the acid's dissolution into a small portion of that water will produce large change in the water's temperature that might cause it to boil and splash from the container, creating a safety hazard.