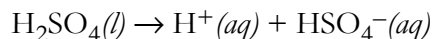


Enthalpy of Diluting Strong Acids Worksheet – Answer Key

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



Calculate ΔH° for this reaction given that the standard state heats of formation for $\text{H}_2\text{SO}_4(l)$, $\text{H}^+(aq)$, and $\text{HSO}_4^-(aq)$ are $-813.989 \text{ kJ/mol}_{\text{rxn}}$, $0 \text{ kJ/mol}_{\text{rxn}}$ (defined), and $-885.75 \text{ kJ/mol}_{\text{rxn}}$, respectively.

$$\Delta H^\circ = [\Delta H^\circ_{\text{f,HSO}_4^-} + \Delta H^\circ_{\text{f,H}^+}] - [\Delta H^\circ_{\text{f,H}_2\text{SO}_4}] = [(-885.75) + 0] - [(-813.989)]$$

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

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 $3.50 \text{ J/g}\cdot^\circ\text{C}$. 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

$$q_{\text{rxn}} = (-71.76 \text{ kJ/mol}_{\text{rxn}}) \times (1 \text{ mol}_{\text{rxn}}/\text{mol H}_2\text{SO}_4) \times (18.0 \text{ mol H}_2\text{SO}_4/\text{L}) \times (0.0100 \text{ L}) \times (1000 \text{ J/kJ}) = -12916.8 \text{ J}$$

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

$$q_{\text{soln}} = -q_{\text{rxn}} = +12916.8 \text{ J} = mS\Delta T = mS(T_{\text{final}} - T_{\text{initial}}) = (100.0 \text{ mL}) \times (1.08 \text{ g/mL}) \times (3.50 \text{ J/g}\cdot^\circ\text{C}) \times (T_{\text{final}} - 25.0^\circ\text{C})$$

$$T_{\text{final}} - 25.0^\circ\text{C} = 34.17^\circ\text{C}$$

$$T_{\text{final}} = 59.2^\circ\text{C}$$

Based on the result of your calculations, speculate on why instructions for preparing dilute solutions of strong acids always emphasize that one should add 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.