TEACHER INFORMATION

Additivity of Heats of Reaction: Hess's Law

1. Editable Microsoft Word versions of the student pages and pre-configured TI-Nspire files can be found on the CD that accompanies this book. See *Appendix A* for more information.

2. Preparation of solutions:

   0.5 M HCl (42.8 mL of concentrated HCl per 1 L solution) **HAZARD ALERT:** Highly toxic by ingestion or inhalation; severely corrosive to skin and eyes. Hazard Code: A—Extremely hazardous.

   1.0 M HCl (85.6 mL of concentrated HCl per 1 L solution) **HAZARD ALERT:** Highly toxic by ingestion or inhalation; severely corrosive to skin and eyes. Hazard Code: A—Extremely hazardous.

   1.0 M NaOH (40.0 g of solid NaOH per 1 L solution) **HAZARD ALERT:** Corrosive solid; skin burns are possible; much heat evolves when added to water; very dangerous to eyes; wear face and eye protection when using this substance. Wear gloves. Hazard Code: B—Hazardous.

   The hazard information reference is: Flinn Scientific, Inc., *Chemical & Biological Catalog Reference Manual*, (800) 452-1261, www.flinnsci.com. See *Appendix F* for more information.

2. It is very important to prepare the solutions at least one day in advance so they will be at room temperature prior to doing the experiment.

3. You should discuss with your students three assumptions made in this lab. One is that the specific heat capacity, C_p, for the aqueous solutions is assumed to be the same as that of pure water, 4.18 J/g°C. They are, in fact, very nearly the same. The second assumption is that the density of the aqueous solutions is 1.00 g/mL. Since this is very nearly the case, we can use a mass of 100 g for 100 mL of solution. The procedure for Reaction 3 uses the assumption that initial HCl solution and NaOH solution temperatures are the same. If you make up the solutions at least one day in advance and store them together, the two temperatures will be the same or nearly the same.

ANSWERS TO PRE-LAB QUESTIONS

Reaction 2 is a combination of Reactions 1 and 3

(1) $NaOH(s) \longrightarrow Na^+(aq) + OH^-(aq)$

(3) $Na^+(aq) + OH^-(aq) + H^+(aq) + Cl^-(aq) \longrightarrow H_2O(1) + Na^+(aq) + Cl^-(aq)$

(2) $NaOH(s) + H^+(aq) + Cl^-(aq) \longrightarrow H_2O(1) + Na^+(aq) + Cl^-(aq)$

SAMPLE RESULTS

Table 1			
	Reaction 1	Reaction 2	Reaction 3
Mass of solid NaOH	2.00 g	1.92 g	(no solid NaOH mass)
Final temperature, t_2	27.0°C	33.8°C	29.1°C
Initial temperature, t_1	22.0°C	22.2°C	22.3°C

Table 2			
	Reaction 1	Reaction 2	Reaction 3
Mass (total) of solution	100.0 g	100.0 g	100.0 g
Change in temperature, Δt	5.0°C	11.6°C	6.8°C
ΔH	$\Delta H = -q = -(2.09\text{ kJ})$ -2.09 kJ	$\Delta H = -q = -(4.85\text{ kJ})$ -4.85 kJ	$\Delta H = -q = -(2.84\text{ kJ})$ -2.84 kJ
Moles of NaOH	(2.00 g)(1 mol/40 g) = 0.0500 mol	(1.92 g)(1 mol/40 g) = 0.0480 mol	(1 mol/L)(0.050 L) = 0.0500 mol
ΔH/mol	$\frac{-2.09\text{ kJ}}{0.0500\text{ mol}} =$ -41.8 kJ/mol	$\frac{-4.85\text{ kJ}}{0.0480\text{ mol}} =$ -101 kJ/mol	$\frac{-2.84\text{ kJ}}{0.0500\text{ mol}} =$ -56.8 kJ/mol
Experimental value kJ/mol	(Reaction 1 + Reaction 3)	$-41.8\text{ kJ} + (-56.8\text{ kJ}) = -98.6$ kJ/mol	
Accepted value kJ/mol	(Reaction 2)		-101 kJ/mol
Percent error	$\frac{\lvert -101-(-98.6)\rvert}{\lvert -101\rvert} \times 100 =$		2.4 %