

### **Lab 5: Thermochemistry**

- **Goal:** In a group of 4 (or otherwise with teacher's discretion) write a protocol to experimentally determine the enthalpy change of a reaction between ammonia and hydrochloric acid as shown below.



- **Challenge:**
  - One of the reactants (ammonia,  $\text{NH}_3$ ) is not available.
  - Use any appropriate techniques or concepts to achieve the above stated goal.

- **Available Materials<sup>1</sup>:**

#### Solutions:

- Hydrochloric acid solution, 2.00 M HCl
- Sodium hydroxide solution, 2.00 M NaOH
- Ammonium chloride solution, 2.00 M  $\text{NH}_4\text{Cl}$

#### Equipment:

- Temperature Probe
  - Labquest
  - 250 mL beaker
  - 50 mL graduated cylinder
  - Calorimeter (150 mL)
  - Glass stirring rod
- **Note:**
    - 50.0 mL of each solution is the maximum allowed volume.
    - The experimental reactions can only be performed once.

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<sup>1</sup> Applicable uncertainties will need to be determined in the lab.

**→ Week #1:**

- ◆ Research topics related to this lab - such as the following:
  - Enthalpy (H)
  - $\Delta H = q$  = heat of the reaction
  - Calorimetry
  - $q = m \cdot c \cdot \Delta T$
  - $q_{\text{reaction}} = -q_{\text{surroundings}}$
  - Hess's Law
- ◆ Watch the following videos:
  - 1) **“Thermochemistry: Heat and Enthalpy”** (4:16):  
<https://www.youtube.com/watch?v=ZVhJ4TO8a-M>
  - 2) **“Hess's Law and Heats of Formation”** (4:57):  
<https://www.youtube.com/watch?v=2q2u5sj4V00&t=133s>
  - 3) **“Heat Capacity, Specific Heat, and Calorimetry”** (4:13):  
<https://www.youtube.com/watch?v=yhNHJ7WdT8A>
- ◆ Prepare your lab notebook as usual.

**→ Week # 2:**

- ◆ Come to your lab period as typical with prepared lab notebook
- ◆ Carry out your experiment.
- ◆ Collect data.

**Follow-Up Work:****Use the Follow-Up Guidelines for details.**

- (1) Title page
- (2) Protocol
  - State what was actually done in the lab.
- (3) Results
- (4) Appendix
  - All calculations with uncertainties.
  - Include Lab Notebook pages of each student in the team (to be graded).

**Due date:**

- Due date: One report per team by the due date and time indicated by your instructor.