Using Hess's Law

HS-PSC-3.2 Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known.

There is no instrument that can directly measure the heat transferred from a system. The best we can do is find the heat received by the surroundings. Using controlled surroundings and $Q=mC\Delta T$ we can get a pretty accurate idea of the heat transfer though. A positive Q means a heat gain (endothermic) while a negative means a heat loss (exothermic).

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In this lab we will find the Q of three reactions and then find the ΔH of each reactions. Here are the three reactions in question.

1. $NaOH_{(aq)} + HCl_{(aq)} \Rightarrow NaCl_{(aq)} + H_2O_{(l)}$
2. $NH_4Cl_{(aq)} + NaOH_{(aq)} \Rightarrow NH_{3(aq)} + NaCl_{(aq)} + H_2O_{(l)}$
3. $NH_{3(aq)} + HCl_{(aq)} \Rightarrow NH_4Cl_{(aq)}$

Materials needed

- Ammonia, NH_3, 2.0 M
- Ammonium Chloride, NH_4Cl, 2.0 M
- Baking Soda, $NaHCO_{3(s)}$
- Hydrochloric acid, HCl, 2.0 M
- Sodium Hydroxide, NaOH, 2.0 M
- Vinegar, $HC_2H_3O_{2(aq)}$

Safety

- Hydrochloric acid causes severe damage to skin and eyes, may be harmful if swallowed or inhaled.
- Sodium hydroxide is extremely corrosive and can cause severe burns to skin or eyes, do not breathe in mist or vapors, do not swallow.
- Ammonium chloride can cause eye or skin irritation.
- Ammonium hydroxide can cause severe burns on skin or eyes. Do not inhale vapors or swallow.
- Perform experiments in a well ventilated room or fume hood.

You will need to make a calorimeter. You can do this using a Styrofoam cup with a thermometer. You will fill the Styrofoam cup with distilled water (or another solution) and find the temperature of the distilled water. After performing the experiment you can find the maximum temperature difference of the water and compare that to the initial temperature. You will lose some heat to the Styrofoam cup as well as the air around the reaction, but for this lab that energy loss will be negligible.

Set up the Databot. Attach a temperature probe and link the databot to your phone using Vizeey.

Experiment 1

Fill the styrofoam cup with 50 mL of HCl 2.0 M and find the initial temperature. Then quickly add 50 mL of NaOH 2.0 M and record the highest temperature the solution after the reaction occurs. You will get the best results by covering the cup while swirling gently. Once you have recorded the data, rinse out the calorimeter and thermometer well for the next experiment.

Experiment 2

You will follow similar instructions as in Experiment 1, instead you will have 50 mL of NH_4Cl 2.0 M in the Styrofoam cup and add 50 mL of NaOH 2.0 M later. Perform this experiment in the fume hood, ammonia gas is evolved from this reaction.

Experiment 3

You will follow similar instructions as in Experiment 1, instead you will have 50 mL of NH_3 2.0 M in the styrofoam cup and add 50 mL of HCl 2.0 M.

	Experiment 1	Experiment 2	Experiment 3
Initial Temperature			
Final Temperature			
Change in Temperature			
Q of reaction			
ΔH of reaction (The Q per 1 mole of reactant)			

Exit Ticket

For your exit ticket, write the net ionic equations for each of the experiments and find the sum of the equations. Then find the sum of the ΔH equations as well.