Chemistry 101 Names:_____

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CALORIMETRY II
An Interactive Lab

Introduction:

In this interactive lab, you will be using an animation available on Profpaz website to study the heat and enthalpy of neutralization of acids and bases, and study the effects of changing volumes, concentrations and other factors on each of these quantities.

Listed below are some important concepts that you should review and consider when completing this worksheet and answering the questions:

- The heat of reaction (q) is commonly calculated in kJ, and in a neutralization reaction its quantity is affected by the number of moles of acid/base that react to neutralize. The greater the number of moles of acid/base neutralized, the greater the value of q.

- The enthalpy of reaction (ΔH) is commonly calculated in kJ/mol of specified substance produced or used in the reaction. For example, in a neutralization reaction enthalpy is measured in kJ/mol of water produced, whereas in a precipitation reaction, it would be measured as kJ/mol precipitate formed. In this manner, the enthalpy of reaction can be compared with other similarly obtained values in literature.

- When writing thermochemical equations, write the balanced equation for the reaction and include the enthalpy (ΔH) with units of kJ associated with the stoichiometry of the reaction.

Experimental:

In this study, you will be performing 4 trials (A–D) outlined on pages 2-5, and you will calculate the heat (q) and enthalpy (ΔH) for each trial and compare them to answer the questions on pages 6-7.

Use the simulation available on profpaz website to complete the experiments described in each of the following sections, (All calculations should be done with 3 significant figures)

A. Heat of Neutralization of an Acid and Base

Use the simulation to determine the heat and enthalpy of reaction for the neutralization of 50.0 mL of 1.00 M HCl and 50.0 mL of 1.00 M NaOH. (Show complete calculations for each step)

Initial temp. of HCl:_____ Initial temp. of NaOH:_____

Final temp. of mixture:_____

(show calculations here)

q = _____ (J) ΔH = _____(kJ/mol H_2O)

Balanced thermochemical equation:

How would the heat (q) and enthalpy of reaction (ΔH) of reaction change if the volumes of each solution in the above experiment were doubled? (Circle your choice for each and provide explanation for your responses)

q:	◯ increase	◯ decrease	◯ does not change
ΔH:	◯ increase	◯ decrease	◯ does not change

B. <u>Heat of Neutralization of an Acid and Base (Change in volume)</u>

Use the simulation to determine the heat and enthalpy of reaction for the neutralization of 100. mL of 1.00 M HCl and 100. mL of 1.00 M NaOH. (Show complete calculations for each step)

Initial temp. of HCl:_____ Initial temp. of NaOH:_____

Final temp. of mixture:_____

(show calculations here)

q = _____ (J) ΔH = _____(kJ/mol H_2O)

Balanced thermochemical equation:

How would the heat (q) and enthalpy of reaction (ΔH) of reaction change if the concentration of each solution in the first experiment were doubled? (Circle your choice for each and provide explanation for your responses)

q: ◯ increase ◯ decrease ◯ does not change

ΔH: ◯ increase ◯ decrease ◯ does not change

C. Heat of Neutralization of an Acid and Base (Change in concentration)

Use the simulation to determine the heat and enthalpy of reaction for the neutralization of 50.0 mL of 2.00 M HCl and 50.0 mL of 2.00 M NaOH. (Show complete calculations for each step)

Initial temp. of HCl:_____ Initial temp. of NaOH:_____

Final temp. of mixture:_____

(show calculations here)

q = _____ (J) ΔH = _____(kJ/mol H_2O)

Balanced thermochemical equation:

How would the heat (q) and enthalpy of reaction (ΔH) of reaction change if a weak acid was reacted with NaOH, in place of a strong acid, in the first experiment? (Circle your choice for each and provide explanation for your responses)

q: ◯ increase ◯ decrease ◯ does not change

ΔH: ◯ increase ◯ decrease ◯ does not change

D. <u>Heat of Neutralization of an Acid and Base (Change in strength)</u>

Use the simulation to determine the heat and enthalpy of reaction for the neutralization of 50.0 mL of 1.00 M acetic acid (HAc)and 50.0 mL of 1.00 M NaOH. (Show complete calculations for each step)

Initial temp. of HAc :_____ Initial temp. of NaOH:_____

Final temp. of mixture:_____

(show calculations here)

q = _____ (J) ΔH = _____(kJ/mol H_2O)

Balanced thermochemical equation:

Questions:

Complete each sentence below by choosing ***greater, lower,*** or ***same*** for each blank. Explanations in each part should contain coherent writing based on chemical concepts learned in the class.

1. *Comparing experiment B with A:*

    a) The change in temperature (ΔT) for experiment B is _____than experiment A.

    b) The change in heat (q) for experiment B is _____ than experiment A.

    c) The change in enthalpy (ΔH) for experiment B is _____than experiment A.

    d) Provide an explanation for the observations above.

2. *Comparing experiment C with A:*

    a) The change in temperature (ΔT) for experiment C is _____than experiment A.

    b) The change in heat (q) for experiment C is _____ than experiment A.

    c) The change in enthalpy (ΔH) for experiment C is _____than experiment A.

    d) Provide an explanation for the observations above.

3. *Comparing experiment D with A:*

   a) The change in temperature (ΔT) for experiment D is _____than experiment A.

   b) The change in heat (q) for experiment D is _____ than experiment A.

   c) The change in enthalpy (ΔH) for experiment D is _____than experiment A.

   d) Provide an explanation for the observations above.

4. In part A, how would the results (ΔT, q and ΔH) change if you used 50.0 mL of 2.00 M HCl and 50.00 mL of 1.00 M NaOH? Give an explanation for your predictions.

5. In part B, how would the results (ΔT, q and ΔH) change is you used 100 mL of 1.00 M HCl and 50 mL of 1.00 M $Ba(OH)_2$? Give an explanation for your predictions.