AP® Chemistry
2002 Sample Student Responses

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ADDITIONAL PAGE FOR ANSWERING QUESTION 5.

a) $q = mc\Delta t$

q: calories
m: grams
c: $\frac{\text{calories}}{\text{grams} \times {}^\circ C}$
ΔT: degrees Celsius

b) • the temperature before the reaction and the temperature after the reaction
• the volume of HCl put in, = the volume of NaOH put in, so that one can find the mass of the solution combined and the moles of H_2O produced

c) i) the number of moles of water produced is equal to the volume of HCl (or NaOH) put in because it is a 1 M solution.

ii) $q_{reaction} = -q_{solution}$

Determine q by multiplying the mass of the combined solution (Density of 1 g/mL times the number of mL of solutions put in) by the specific heat for water, c, and the change in temperature (temperature after - temperature before). This gives you q of the solution, in calories. The q of the reaction has the opposite sign. Divide the $q_{reaction}$ value by the number of moles of water produced to get the molar enthalpy of neutralization.

d) i) The value of q will increase. More moles of substance will create a greater temperature change, even though the masses remain the same.

ii) The molar enthalpy of neutralization will stay the same. The amount of heat produced will increase because more moles are produced, but dividing it by the number of moles will bring it back to a constant.

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ADDITIONAL PAGE FOR ANSWERING QUESTION 5.

e) it would decrease $\Delta H_{neut.}$ The temperature change would not appear as great as it should be, so it would seem that less heat was produced/ needed for the reaction.

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ADDITIONAL PAGE FOR ANSWERING QUESTION 5.

a. m = grams q = joules
$\Delta T = °C$
$c = \frac{\text{joules}}{g \cdot °C}$

b. Measure the temperature before mixing
Measure the temperature after mixing
Measure the volume of the mixture (which is also mass)
C of H_2O needs to be given.

c. i Since Acid HCl and Base NaOH are both strong, they will go to completion and produce water. So since the molarity of HCl 1.0M, you multiply this by the volume used and get number of moles of water since $H^+ + OH^- \rightarrow H_2O$ have the same coefficients and equal HCl and NaOH are added.

ii Find all the necessary measurments and plug it into $q = mc\Delta T$. ΔT is $= T_{final} - T_{initial}$. You find q and q = joules. Divide q by 1000 to get KJ and if q is positive then ΔH is negative and vice versa.

d i q increases since mass increases in the equation $q = mc\Delta T$

ii ΔH will stay the same since it is calculated as per mole of H_2O which is the equation: $H^+(aq) + OH^-(aq) \rightarrow H_2O(l)$ in simplest form.

e. ΔH_{neut} would be less than what it should be because if heat is lost then ΔT would be smaller thus making q smaller

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ADDITIONAL PAGE FOR ANSWERING QUESTION 5.

a) q = Joules m = gram C = g/°C ΔT = °C

b) - mass of sample
- temperature change

c) i) since all of the OH^- and H^+ ions will react to form H_2O, the moles of H_2O can be found using $M = \frac{n}{V}$, where M is the molarity, n is the number of moles of either OH^- or H^+, and V is the volume of the container. the values for OH^- and H^+ will be equal, and are also equal to the moles of H_2O.

ii) using $Q = mC_p\Delta T$, the heat of neutralization can be found. Use the C_p of H_2O, and the moles converted to grams of the H_2O calculated in "i". Divide by # of moles to get molar ΔH_{neut}.

d) i) The value of q will increase because there are twice as many moles of reactant as in the first experiment. when more molecules react, more heat is produced.

ii) The molar heat of neut will stay the same. A molar ΔH of formation is an intensive property and will never change.

e) The ΔH_{neut} would appear to be larger because a larger amount of heat would be necessary to raise the temperature the same amount and react all of the reactants.

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