Enthalpy of a strong acid – strong base reaction

10.0 cm^3 of sodium hydroxide solution were placed in an insulated container, initially at 17.0 ^OC, and 2.00 mol L^{-1} hydrochloric acid, $HCl_{(aq)}$, also at 17.0 ^OC was added in fixed amounts, the temperature was taken after each addition. The following data was collected:

Volume of $HCl_{(aq)}$ ($\pm$ 0.05 cm^3)	**Temperature ($\pm$ 0.1 ^OC)**
0.00	17.0
2.00	19.0
4.00	21.0
6.00	23.0
8.00	25.0
10.00	27.0
12.00	29.0
14.00	29.0
16.00	28.0
18.00	27.0
20.00	26.0
22.00	25.0
24.00	24.0
26.00	23.0

Answer the following questions:

a. Plot a graph of these results with volume of hydrochloric acid on the x-axis.
b. For what volume of $HCl_{(aq)}$ does maximum temperature rise occur?
c. What has happened when the temperature reaches maximum?
d. Why does the temperature drop after the maximum?
e. How much heat was absorbed by the solution when the maximum temperature was observed? (Assume solution is water, c (water) = 4.17 J/g.^OC)
f. How many moles of $HCl_{(aq)}$ in the volume of acid were required for the maximum temperature rise?
g. What would be the heat change if 1.00 mol of $HCl_{(aq)}$ had been used?
h. Write a balanced chemical equation for the reaction of $HCl_{(aq)}$ with $NaOH_{(aq)}$
i. Write a thermochemical equation for the reaction of $HCl_{(aq)}$ with $NaOH_{(aq)}$.
j. Calculate the concentration of the $NaOH_{(aq)}$.
k. Write a net-ionic equation for the reaction of $HCl_{(aq)}$ with $NaOH_{(aq)}$
l. Consider the net-ionic equation, explain in terms of bond-breaking and bond making if you expect the reaction to be an endothermic ot an exothermic process.
m. Explain how the magnitude of the enthalpy would differ if the neutralization reaction was carried out using acetic acid, $CH_3COOH_{(aq)}$, instead of hydrochloric acid, with sodium hydroxide.

Answers: Enthalpy of Strong Acid - Strong Base Reaction

a See graph.

b. V = 13.00 cm^3

c. Reaction has gone to completion

d. Heat transfer with air & surroundings after reaction is complete

e. Q = –1246.83 J (negative because exothermic; heat is exiting system)

f. n = 0.026 moles

g. ? H = – 47.96 kJ = — 48.0 $kJmol^{-1}$

h. $HCl_{(aq)} + NaOH_{(aq)} \text{ — > } H_2O_{(l)} + NaCl_{(aq)}$

i. $HCl_{(aq)} + NaOH_{(aq)} \text{ — > } H_2O_{(l)} + NaCl_{(aq)} + 48.0\ kJ$

j. c = 2.60 mol dm^{-3}

k. $H^{+1}_{(aq)} + OH^{-1}_{(aq)} \longrightarrow H_2O_{(l)}$

l. Bond being made, co-ordinate (dative) bond, releases energy, .: exothermic

m. Value expected to be lower, since acetic acid, $CH_3COOH_{(aq)}$ is a weak acid, only partially ionized thus less bonds made.