

Heat, enthalpy and Hess's law

AP Chemistry · Lab answers

The sample data give ΔH_3 of about -56 kJ/mol, within 2 % of the accepted value. Notice that both runs use the same experimental technique, so some systematic errors such as heat loss partly cancel when ΔH_1 is subtracted from ΔH_2 .

Level: AP Chemistry · **Curriculum:** AP Chem Unit 6

Question 1 Fair test

The heat released depends on the amount of NaOH and the mass being heated. With equal mass and volume, ΔT depends only on the process, and **the two runs can be compared** through Hess's law.

Question 2 Dissolving

$\Delta T = 5.2$ °C; $q = 102.0 \times 4.18 \times 5.2 = 2217$ J. $n = 2.00/40.00 = 0.0500$ mol. $\Delta H_1 = -2.217/0.0500 = \mathbf{-44.3}$ kJ/mol.

Question 3 Reaction with acid

$\Delta T = 11.8$ °C; $q = 102.0 \times 4.18 \times 11.8 = 5031$ J; $\Delta H_2 = -5.031/0.0500 = \mathbf{-101}$ kJ/mol.
 $n(\text{HCl}) = 0.1000 \times 0.500 = 0.0500$ mol, equal to $n(\text{NaOH})$.

Question 4 Hess's law

Cycle: $\text{NaOH(s)} \rightarrow \text{NaOH(aq)}$ (ΔH_1), then $\text{NaOH(aq)} + \text{HCl(aq)} \rightarrow \text{products}$ (ΔH_3); the direct route is ΔH_2 . So $\Delta H_3 = \Delta H_2 - \Delta H_1 = -100.6 - (-44.3) = \mathbf{-56.3}$ kJ/mol.

Question 5 Comparison

Difference = $(57.3 - 56.3)/57.3 \times 100 = \mathbf{1.7}$ %, a small discrepancy.

Question 6 Direction of errors

Heat lost to the room lowers the highest temperature, so each $|\Delta H|$ is **too small**. Other errors: the density and specific heat of the solution are not exactly those of water; NaOH pellets absorb moisture, so the real mass of NaOH is less than 2.00 g.

Question 7 Improvement

Plot temperature against time and extrapolate to the mixing time; use a lid and a second

insulating cup; weigh NaOH quickly in a closed bottle; repeat and take a mean. **Any two** of these.