Problema 421: Calcula ΔH^o de las reacciones, y comprueba que se cumple la Ley de Hess.

$$NaOH_{(s)} \rightarrow NaOH_{(aq)}$$
$$NaOH_{(aq)} + HCl_{(aq)} \rightarrow NaCl_{(aq)} + H_2O_{(l)}$$
$$NaOH_{(s)} + HCl_{(aq)} \rightarrow NaCl_{(aq)} + H_2O_{(l)}$$

Sumando las dos primeras reacciones obtenemos la tercera, sumando los calores de las dos primeras debemos obtener el calor de la tercera según la ley de Hess.

a) $NaOH_{(s)} \rightarrow NaOH_{(aq)}$

$NaOH_{(s)} \rightarrow Na^+_{(aq)} + OH^-_{(aq)}$

$$\Delta H^o_R = \Sigma n_p \cdot \Delta H^o_{f\,prod} - \Sigma n_r \cdot \Delta H^o_{f\,react}$$

$$\Delta H^o_R = 1\,mol \cdot \Delta H^o_f[Na^+_{(aq)}] + 1\,mol \cdot \Delta H^o_f[OH^-_{(aq)}] - 1\,mol \cdot \Delta H^o_f[NaOH_{(s)}]$$

$$\Delta H^o_R = 1\,mol \cdot \left(-240{,}0\,\frac{kJ}{mol}\right) + 1\,mol \cdot \left(-229{,}9\,\frac{kJ}{mol}\right) - 1\,mol \cdot \left(-426{,}7\,\frac{kJ}{mol}\right) = \underline{-43{,}2\,kJ}$$

b) $NaOH_{(aq)} + HCl_{(aq)} \rightarrow NaCl_{(aq)} + H_2O_{(l)}$

$Na^+_{(aq)} + OH^-_{(aq)} + H^+_{(aq)} + Cl^-_{(aq)} \rightarrow Na^+_{(aq)} + Cl^-_{(aq)} + H_2O_{(l)}$

$$\Delta H^o_R = \Sigma n_p \cdot \Delta H^o_{f\,prod} - \Sigma n_r \cdot \Delta H^o_{f\,react}$$

$$\Delta H^o_R = 1\,mol \cdot \Delta H^o_f[Na^+_{(aq)}] + 1\,mol \cdot \Delta H^o_f[Cl^-_{(aq)}] + 1\,mol \cdot \Delta H^o_f[H_2O_{(l)}] -$$
$$- 1\,mol \cdot \Delta H^o_f[Na^+_{(aq)}] - 1\,mol \cdot \Delta H^o_f[OH^-_{(aq)}] - 1\,mol \cdot \Delta H^o_f[H^+_{(aq)}] - 1\,mol \cdot \Delta H^o_f[Cl^-_{(aq)}]$$

$$\Delta H^o_R = 1\,mol \cdot \Delta H^o_f[H_2O_{(l)}] - 1\,mol \cdot \Delta H^o_f[OH^-_{(aq)}] - 1\,mol \cdot \Delta H^o_f[H^+_{(aq)}]$$

$$\Delta H^o_R = 1\,mol \cdot \left(-285{,}0\,\frac{kJ}{mol}\right) - 1\,mol \cdot \left(-229{,}9\,\frac{kJ}{mol}\right) - 1\,mol \cdot 0\,\frac{kJ}{mol} = \underline{-55{,}1\,kJ}$$

c) $NaOH_{(s)} + HCl_{(aq)} \rightarrow NaCl_{(aq)} + H_2O_{(l)}$

$NaOH_{(s)} + H^+_{(aq)} + Cl^-_{(aq)} \rightarrow Na^+_{(aq)} + Cl^-_{(aq)} + H_2O_{(l)}$

$$\Delta H^o_R = \Sigma n_p \cdot \Delta H^o_{f\,prod} - \Sigma n_r \cdot \Delta H^o_{f\,react}$$

$$\Delta H^o_R = 1\,mol \cdot \Delta H^o_f[Na^+_{(aq)}] + 1\,mol \cdot \Delta H^o_f[Cl^-_{(aq)}] + 1\,mol \cdot \Delta H^o_f[H_2O_{(l)}] -$$
$$- 1\,mol \cdot \Delta H^o_f[NaOH_{(s)}] - 1\,mol \cdot \Delta H^o_f[H^+_{(aq)}] - 1\,mol \cdot \Delta H^o_f[Cl^-_{(aq)}]$$

$$\Delta H^o_R = 1\,mol \cdot \Delta H^o_f[Na^+_{(aq)}] + 1\,mol \cdot \Delta H^o_f[H_2O_{(l)}] - 1\,mol \cdot \Delta H^o_f[NaOH_{(s)}] - 1\,mol \cdot \Delta H^o_f[H^+_{(aq)}]$$

$$\Delta H^o_R = 1\,mol \cdot \left(-240{,}0\,\frac{kJ}{mol}\right) + 1\,mol \cdot \left(-285{,}0\,\frac{kJ}{mol}\right) - 1\,mol \cdot \left(-426{,}7\,\frac{kJ}{mol}\right) - 1\,mol \cdot 0\,\frac{kJ}{mol} = \underline{-98{,}3\,kJ}$$

$$\Delta H^o_A + \Delta H^o_B = -43{,}2\,kJ - 55{,}1\,kJ = -98{,}3\,kJ = \Delta H^o_C$$