15.7.1: Lecture Demonstrations

Calorimeter Constant

To a styrofoam cup calorimeter containing 250 mL of water at 24.0 ^oC is added a known amount of heat as 250 mL of water from a second styrofoam cup at 32.0 ^oC. The final temperature, measured by a computer-interfaced thermistor, is 27.7 ^oC. The computer-generated plot of T vs. time should be projected[1]. What is the calorimeter constant?

$\Delta T_{\text{calorimeter}} = 27.7\ ^oC – 24.0\ ^oC = 3.7\ ^oC$

$\Delta T_{\text{cold}} = 27.5\ ^oC – 24.0\ ^oC = 3.7\ ^oC$

$\Delta T_{\text{hot}} = 27.7 – 32.0 = -4.3\ ^oC$

$q_{\text{hot}} = m \text{ x S.H. x } \Delta T = 250 \text{ g x } 4.18 \text{ J/g}^oC \text{ x } -4.3^oC = -4494 \text{ J}$

$q_{\text{cold}} = m \text{ x S.H. x } \Delta T = 250 \text{ x } 4.18 \text{ x } 3.7\ ^oC = 3867 \text{ J}$

$q_{\text{calorimeer}} + q_{\text{hot}} + q_{\text{cold}} = 0$

$q_{\text{calorimeter}} -4494 + 3867 = 0$

$q_{\text{calorimeter}} = 627$ J.

$C = Q_{\text{calorimeter}}/T = 627 \text{ J} / 3.7\ ^oC = 169 \text{ J/}^oC$

The Ammonium Nitrate "Cold Pack"[2]

A styrofoam cup calorimeter contains 250 mL of water at 25.0^oC. Solid NH_4NO_3 (5 g) is added, and the temperature falls to 23.8^oC. The computer-generated plot of T vs. time should be projected[3]. The calorimeter is found to absorb 169 J to change its temperature 1 ^oC, so it is said to have a calorimeter constant of 169 J/^oC. What is the enthalpy change for the dissolution reaction?

$q_{\text{water}} = m \text{ x S.H. x } \Delta T = 250 \text{ g x } 4.18 \text{ J/g}^oC \text{ x } -1.2^oC$

$= -1254$ J

$q_{\text{calorim}} = C \text{ x } \Delta T = 169 \text{ x } -1.2^oC = -203 \text{ J}$

$q_{\text{tot}} = -1254 + -203 = -1457$ J

$q_{\text{rxn}} = +1457$ J.

$\Delta H_{\text{rxn}} = q \text{ (kJ) / n (mol)}$

$n = m / M = 5 \text{ g } NH_4NO_3 / 80 \text{ g/mol} = 0.057 \text{ mol}$

$\Delta H_{\text{rxn}} = q/n = 1.457 \text{ kJ} / 0.057 \text{ mol} = +25.6 \text{ kJ/mol}$

The reaction is spontaneous even though it is endothermic, because of the large positive entropy change resulting from water association with the separate ions in solution.

References

1. We used Vernier LoggerPro(R) software
2. J. Chem. Educ., 2004, 81 (1), p 64A
3. We used Vernier LoggerPro(R) software

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