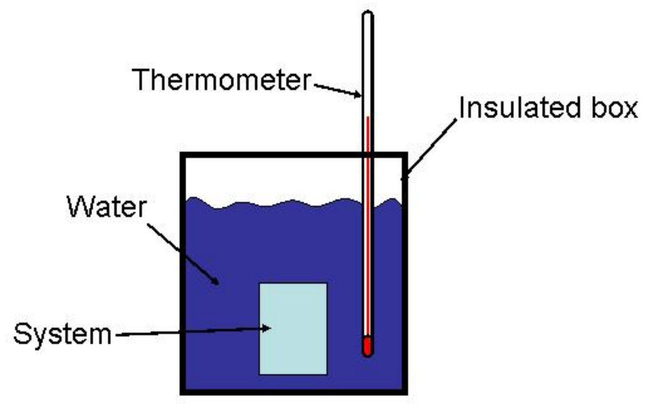
Rafa Muñoa
Lizardi Institutua
Zarautz

Calorimetry: exercises

1. Acetylene (C_2H_2) is used in welding torches because it has a high heat of combustion. When 1.00 g of acetylene burns completely in excess O_2 gas at constant volume, it releases 48.2 kJ of energy
a) What is the balanced chemical equation for this reaction?
b) What is the molar energy of combustion of acetylene?
c) How much energy is released per mole of O_2 consumed?
Atomic weights: C=12; H=1

2. A chemical engineer studying the properties fo fuels placed 1.5 g of a hydrocarbon in a bomb of a calorimeter and filled it with O_2 gas. The bomb was inmersed in 2.5 L water and the reaction initiated. The water temperature rose from 20.00 ºC to 23.55ºC. If the calorimeter (excluding the water) had a heat capacity of 403 J/K, what was the heat of combustion (q_v) per gram of the fuel?

c (water) = 4180 J/Kg.K



http://chemlab.truman.edu/CHEM120Labs/CalorimetryFiles/CalFig1.gif

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Zarautz

Calorimetry: exercises

3. How much heat is needed to warm 250 g of water from 22ºC (about room temperature) to near its boiling point, 98ºC? The specific heat of water is 4.18 J/g.K

4. When a 6.5 g sample of solid sodium hydroxide dissolves in 100 g of water in a constant-pressure calorimeter, the temperature raises from 21.6 ºC to 37.8 ºC. Calculate ΔH (in kJ/mol NaOH) for the solution process

$$NaOH\,(s) \rightarrow Na^{+}(aq) + OH^{-}(aq)$$

Assume that the specific heat of the solution is the same as that of pure water: 4.18 kJ/kg.K

Atomic weight: Na=23; O=16; H=1

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a) What is the balanced chemical equation for this reaction?

$$C_2H_2 + 2.5\ O_2\ (g) \rightarrow 2\ CO_2\ (g) + H_2O\ (l)$$

b) What is the molar energy of combustion of acetylene?

$$M = (2*12) + (2*1) = 26\ g/mol$$

$$Qv = \frac{48.2\ kJ}{1\ g}\ \frac{26\ g}{1\ mol} = 1253\ \frac{kJ}{mol\ C_2H_2}$$

c) How much energy is released per mole of O_2 consumed?

$$Qv = 1253\ \frac{kJ}{mol\ C_2H_2}\ \frac{1\ mol\ C_2H_2}{2.5\ mol\ O_2} = 501.3\ \frac{kJ}{mol\ O_2}$$

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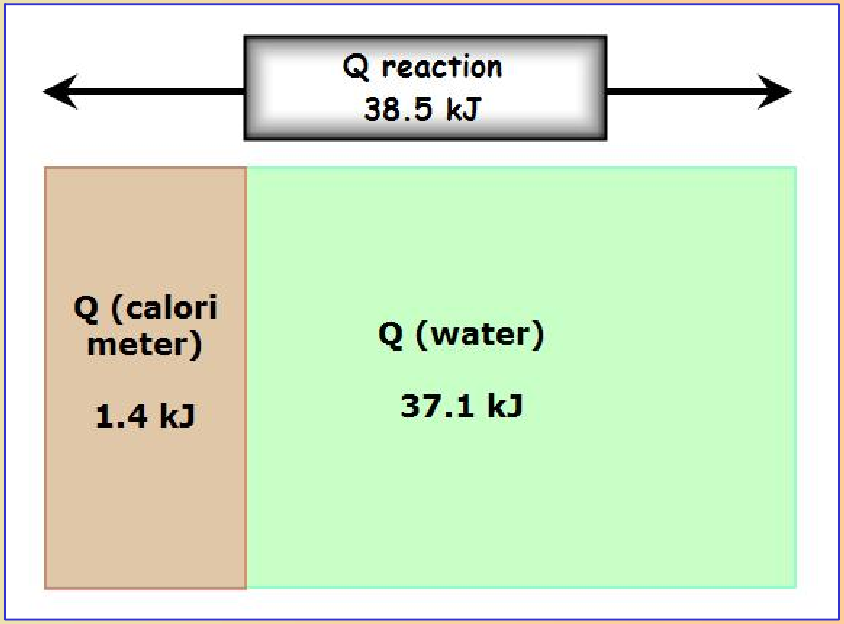

$$Q_{calorimeter} = C_{cal} * \Delta T + m_{H2O} * c_{H2O} * \Delta T$$

$$\Delta T = 23.55\ ºC - 20.00\ ºC = 3.55\ ºC = 3.55\ K$$

$$Q_{calorimeter} = 403\ \frac{J}{K} * 3.55\ K + 2.5\ kg * 4180\ \frac{J}{kg.K} * 3.55\ K$$

$$Q_{calorimeter} = 1430.65\ J + 37097.5\ J = 38.5\ kJ = -\ Qv_{reaction}$$

$$Qv = \frac{-38.5\ kJ}{1.5\ g\ \ fuel} = -\ 25.7\ \frac{kJ}{g\ \ fuel}$$

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$$Q = m * c * \Delta T$$

$$Q = 250\ g * 4.18\ \frac{J}{g.ºC} * (98\ ºC - 22\ ºC) = 79420\ J = 79.42\ kJ$$

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

Assume that the specific heat of the solution is the same as that of pure water:
4.18 kJ/kg.K

$$Q_p = m * c * \Delta T = \frac{106.5}{1000}\ kg * 4.18\ \frac{kJ}{kg\ K} * (37.8\ ºC - 21.6\ ºC) = 7.21\ kJ$$

$$M = 23 + 16 + 1 = 40\ g/mol$$

$$Q_p = \Delta H_{sol} = \frac{7.21\ kJ}{6.5\ g}\ \frac{40\ g}{1\ mol} = 44.37\ \frac{kJ}{mol}$$