Thermochemistry 1

1. When 25.0 g of an unknown metal at 79.7°C is placed in a calorimeter with a heat capacity of 62.5 J/C° containing 125 g of H_2O at 22.2°C, thermal equilibrium is reached at 24.6°C. What is the specific heat capacity of the metal?

$$-q_{lost} = q_{gained}$$

$$-q_{metal} = q_{water} + q_{calorimeter}$$

$$-m_{metal} C_{metal} \Delta T_{metal} = m_w C_w \Delta T_w + H_c \Delta T_w$$

$$-(25.0\,g)(C_{metal})(-55.1°) = (125\,g)(4.184\,J/g°)(2.4°) + (62.5\,J/°)(2.4°)$$

$$(1377.5\,g·°)\,C_{metal} = 1255.2\,J + 150\,J$$

$$C_{metal} = 1.0\,J/g°$$

2. What will be the final temperature if a 45.0-g piece of zinc at 80.0°C is dropped into 125.0 g of water at 18.2°C? (Assume no heat is lost to the environment or the container.)

$$-q_{lost} = q_{gained}$$

$$-m_{Zn} C_{Zn} (T_f - T_i)_{Zn} = m_{H_2O} C_{H_2O} (T_f - T_i)_{H_2O}$$

$$-(45.0\,g)(0.388\,J/g°)(T_f - 80.0°C) = (125.0\,g)(4.184\,J/g°)(T_f - 18.2°C)$$

$$-17.46\,T_f + 1396.8 = 523\,T_f - 9518.6$$

$$10915.4 = 540.46\,T_f$$

$$T_f = 20.2°C$$

3. Consider the gas-phase reaction below, for which ΔH = –124.1 kJ: $2\,SO_2 + O_2 \rightarrow 2\,SO_3$

   Calculate the quantity and sign of the heat associated with the production of 1.00 kg of SO_3 by this process.

$$\frac{1.00\,kg}{1} \left| \frac{1000\,g}{1\,kg} \right| \frac{1\,mol\,SO_3}{80.06\,g} \left| \frac{-124.1\,kJ}{2\,mol\,SO_3} \right| = -775\,kJ$$

4. The combustion of 1.33-g of a propene (C_3H_6) results in the release of 3,370 J of heat. What is the enthalpy of combustion of propene in kJ/g and in kJ/mol?

$\frac{1.33\,g \mid 1\,mol}{42.09\,g} = 0.03160\,mol$ $\quad q = -3370\,J$

$\Delta H = \frac{-3370\,J}{1.33\,g} = -2530\,J/g = -2{,}530\,kJ/g$

$\Delta H = \frac{-3370\,J}{0.03160\,mol} = -107{,}000\,J/mol = -107\,kJ/mol$

5. What is the mass of a piece of nickel metal if it is heated to 100.0°C and placed into 250.0 grams of water at 21.52 °C in a calorimeter with a heat capacity of 95.3 J/K and the temperature stabilizes at 25.82 °C?

$-q_{Ni} = q_{H_2O} + q_{calorimeter}$

$-m_{Ni} C_{Ni} \Delta T_{Ni} = m_{H_2O} C_{H_2O} \Delta T_{H_2O} + H_c \Delta T_{calorimeter}$

$\Delta T_{Ni} = 25.82 - 100 = -74.18\,C^\circ$ $\quad \Delta T_{H_2O} = \Delta T_{cal} = 25.82 - 21.52 = 4.30$

$-m_{Ni}(0.444\,J/g{}^\circ)(-74.18\,C^\circ) = (250\,g)(4.184\,J/g{}^\circ)(4.30^\circ) + (95.3\,J/{}^\circ)(4.30^\circ)$

$32.95\,m_{Ni} = 4497.8 + 409.73$

$m_{Ni} = 149\,g$