AP CHEMISTRY

TOPIC 9: THERMODYNAMICS, PART A, EXAMPLES, PART II Day 108:

- Laws of Thermodynamics
- Enthalpy
- Specific Heat

Example #1: An unknown metal, with a mass of 30 grams, is in a beaker of boiling water, at a temperature of 102 ^{0}C, after a few minutes, the metal IS QUICKLY moved (and in our "perfect lab set-up" no heat was lost to the surroundings) to the calorimeter with 120 grams of water at a temperature of 19 ^{0}C. After a small amount of time the temperature of the water in the calorimeter changed (and stopped changing) to 21.3 ^{0}C. What is the specific heat of the metal?

	H_2O	Metal
m	120 g	30 g
T_i	19^0C	102^0C
T_f	21.3^0C	21.3^0C
c	4.184	?

$$q_{H_2O} = mc\Delta T \;;\; q_{H_2O} = (120\ g)\left(\frac{4.184\ J}{g\ ^0C}\right)\left(21.3^0C - 19^0C\right) = 1154.784\ J$$

$$q_{metal} = mc\Delta T \;;\; q_{metal} = -1154.784\ J = (30\ g)(c)\left(21.3^0C - 102^0C\right)$$

$$c_{metal} = \frac{-1154.784\ J}{(30\ g)\left(21.3^0C - 102^0C\right)} = 0.477\frac{J}{g\ ^0C}$$

In this second type of sample, the enthalpy of a reaction can be determined from the heat of the reaction, which will take place at constant atmospheric pressure.

Example #2, In this problem, 75.0 mL of 0.10 *M* $Pb(NO_3)_2$ and 50.0 mL of 0.23 *M* HCl are mixed together. First, will this reaction occur? If so what is the NET equation of this reaction?

$$Pb(NO_3)_2 + 2\ HCl \rightarrow PbCl_{2\ (s)} + 2\ HNO_3$$

$$\text{(net)}\quad Pb^{+1} + 2\ Cl^{-1} \rightarrow PbCl_{2\ (s)}$$

The initial temperature of the solution was 25 ^{0}C, and the final temperature was 25.8 ^{0}C. Determine the enthalpy, in kJ / mol, for the formation of the product (if there is one ???). The volume of the final solution was 125 mL, and it had a density of 1.05 g/mL. The specific heat of water is 4.18 J / g ^{0}C.

$$\frac{125\ mL}{} \times \frac{1.05\ g}{1\ mL} = 131.25\ g$$

$$q_{H_2O} = (131.25\ g)\left(\frac{4.18\ J}{g\ ^0C}\right)\left(25.8^0C - 25^0C\right) = \frac{438.9\ J}{} \times \frac{1\ kJ}{1000\ J} = 0.4389\ kJ$$

Limiting Reactant STEP:

$$\frac{75\ mL}{} \times \frac{1\ L}{1000\ mL} \times \frac{0.10\ mol\ Pb(NO_3)_2}{L} \times \frac{2\ mol\ HCl}{1\ mol\ Pb(NO_3)_2} \times \frac{L}{0.23\ mol\ HCl} \times \frac{1000\ mL}{1\ L} = 65.2\ mL\ HCl$$

HCl is the Limiting Reactant. If one used 75 mL of 0.1 *M* $Pb(NO_3)_2$ one would **NEED** 65.2 mL of 0.23 *M* HCl. There is **ONLY** 50 mL of HCl, there is **NOT ENOUGH** HCl to completely react with the $Pb(NO_3)_2$, therefore HCl is the Limiting Reactant.

$$\frac{50\ mL}{} \times \frac{1\ L}{1000\ mL} \times \frac{0.23\ mol\ HCl}{L} \times \frac{1\ mol\ PbCl_2}{2\ mol\ HCl} = 0.00575\ mol\ PbCl_2$$

$$\Delta H = \frac{0.4389\ kJ}{0.00575\ mol\ PbCl_2} = 76.3\ \frac{kJ}{mol}$$