AP CHEMISTRY

TOPIC 9: THERMODYNAMICS, PART A,

Day 108:

- Laws of Thermodynamics
- Enthalpy
- Specific Heat

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1. A 2.50 kg piece of copper metal is heated from 25 ^{0}C to 225 ^{0}C. How much heat, in kJ, is absorbed by the copper ? The specific heat for copper is 0.384 J / g ^{0}C.

$$q = m\ c\ \Delta T$$

$$q = (2500\ g)\left(\frac{0.384\ J}{g\ ^0C}\right)(225^0C - 25^0C) = 1.92\times10^5\ J$$

$$\frac{1.92\times10^5\ J}{} \times \frac{1\ kJ}{1000\ J} = 192\ kJ$$

2. Determine if the following processes are endothermic or exothermic? Then **Explain why**.

   a) When solid potassium bromide (***ENDO***) is dissolved in water (***EXO***), the solution gets colder.

   Potassium Bromide = Endothermic (absorbed energy from the water to dissolve).

   b) Natural gas (CH_4) is burned (***EXO***) in a furnace to heat the house (***ENDO***).

   Natural Gas = Exothermic, (Air in the house absorbs the energy from the combustion of the gas)

   c) When concentrated H_2SO_4 (***EXO***) is added to water (***ENDO***), the solution gets very hot.

   H_2SO_4 is Exothermic, (the water absorbs the energy from the sulfuric acid to get hot)

   d) Water (***ENDO***) is boiled in a teakettle while sitting on the stove "element" (***EXO***).

   Water is Endothermic, (the water absorbs the energy from the stove to boil)

3. The complete combustion of glucose, $C_6H_{12}O_6$, in oxygen gas, O_2, produces carbon dioxide and water. It is a highly exothermic process releasing 1273.02 kJ of heat per mole of glucose. Write the balanced thermochemical equation, using all whole-number coefficients. Also, determine the enthalpy change in burning 250.0 grams of glucose.

$$C_6H_{12}O_{6\ (s)} + 6\ O_{2\ (g)} \rightarrow 6\ CO_{2\ (g)} + 6\ H_2O_{(g)}\ ;\ \Delta H = -\ 1273.02\ kJ$$

Since we have one mole of glucose represented (from the balanced equation above) we do not need to re-write the equation in "fractional form"

For the second part of this question, you know that the enthalpy change for one mole butane is – 1273.02 kJ. All you need to do is determine what fraction of a mole 250.0 grams is and reduce the enthalpy by that amount:

$$\frac{250.0\ g\ C_6H_{12}O_6}{} \times \frac{1\ mol}{180.1608\ g\ C_6H_{12}O_6} = 1.388\ mol\ C_6H_{12}O_6$$

$$\frac{1.388\ mol\ C_6H_{12}O_6}{} \times \frac{-1273.02\ kJ}{1\ mol} = -1767\ kJ$$

4. An unknown metal, with a mass of 125 grams, is in a beaker of boiling water, at a temperature of 99.87 ^{0}C, after a few minutes, the metal IS QUICKLY moved to the calorimeter with 250 milliliters of water at a temperature of 293 K. After a small amount of time has passed, the temperature of the water in the calorimeter changed (and stopped changing) to 297.3 K. What is the specific heat of the metal (with the correct units for specific heat)?

	H_2O	Metal
m	250 g	125 g
T_i	20^{0}C	99.87^{0}C
T_f	24.3^{0}C	24.3^{0}C
c	4.184	?

$$q_{H_2O} = mc\Delta T \;\; ; \;\; q_{H_2O} = (250\ g)\left(\frac{4.184\ J}{g\ ^0C}\right)(24.3^0C - 20^0C) = 4497.8\ J$$

$$q_{metal} = mc\Delta T \;\; ; \;\; q_{metal} = -4497.8\ J = (125\ g)(c)(24.3^0C - 99.87^0C)$$

$$c_{metal} = \frac{-4497.8\ J}{(125\ g)(-75.57^0C)} = 0.476\frac{J}{g\ ^0C}$$

5. In this problem, 157.0 mL of 0.350 *M* $Pb(ClO_3)_2$ and 75.3 mL of 0.220 *M* $CuSO_4$ are mixed together. First, will this reaction occur? If so what is the NET equation of this reaction?

$$Pb(ClO_3)_2 + CuSO_4 \rightarrow PbSO_4 + Cu(ClO_3)_2$$

$$\text{(net)}\quad Pb^{+2} + SO_4^{-2} \rightarrow PbSO_4$$

The initial temperature of the solution was 19 ^{0}C, and the final temperature was 32.8 ^{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 232.3 mL, and it had a density of 1.085 g/mL. The specific heat of water is 4.18 J / g ^{0}C.

$$\frac{232.3\ mL}{} \times \frac{1.085\ g}{1\ mL} = 252.0455\ g$$

$$q_{H_2O} = (252.0455\ g)\left(\frac{4.184\ J}{g\ ^0C}\right)(32.8^0C - 19^0C) = 14552.91\ J$$

$$\frac{14552.91\ J}{} \times \frac{1\ kJ}{1000\ J} = 14.55291\ kJ$$

Limiting Reactant?

$$\frac{157.0\ mL}{} \times \frac{1\ L}{1000\ mL} \times \frac{0.350\ mol\ Pb(ClO_3)_2}{L} \times \frac{1\ mol\ CuSO_4}{1\ mol\ Pb(ClO_3)_2} \times \frac{L}{0.222\ mol\ CuSO_4} \times \frac{1000\ mL}{1\ L} = 247.5\ mL$$

Copper(II) sulfate is the Limiting Reactant. Recall, if you use ALL 157 mL of the lead(II) chlorate you would NEED AT LEAST 247.5 mL of the copper(II) sulfate – you only have 75.3 mL.

Number of moles or Reactant:

$$\frac{75.3\ mL}{} \times \frac{1\ L}{1000\ mL} \times \frac{0.220\ mol\ CuSO_4}{L} \times \frac{1\ mol\ PbSO_4}{1\ mol\ CuSO_4} = 0.016566\ mol\ PbSO_4$$

$$\Delta H = \frac{14.55291\ kJ}{0.016566\ mol\ PbSO_4} = 878\ \frac{kJ}{mol}$$