Chemistry II
Enthalpy Worksheet

Name ____________________

As we have studied heat capacity and specific heat capacity, we've learned how heat can be exchanged between objects. Heat can also be exchanged during a chemical reaction. In an exothermic chemical reaction, heat is a product; while in an endothermic chemical reaction, heat is a reactant. The heat of a reaction, which is the change in energy of the products and reactants, is referred to as *Enthalpy*. For example, in the reaction of calcium oxide and water heat is released from the reaction and calcium hydroxide is formed, as shown in the equation below:

$$CaO(s) + H_2O(l) \rightarrow Ca(OH)_2(s) + 65.2kJ$$

In this reaction, the release of energy indicates that the total energy of the reactants is greater than the energy of the product. The amount of heat that is released is generally referred to as the *change in enthalpy* (ΔH) between the reactants and products. ΔH is equal to $H_{products} - H_{reactants}$. Because enthalpy (H) is, in a sense, a measure of the internal energy of a substance, it is impossible to calculate, but we can use changes in heat to measure changes in H. We when refer to the change in enthalpy, the chemical reaction can be written as follows:

$$CaO(s) + H_2O(l) \rightarrow Ca(OH)_2(s) \qquad \Delta H = -65.2kJ$$

Notice that the change in enthalpy is negative, which means that heat from the reactants (system) was given off to the surroundings. This is an exothermic reaction, which is indicated by a negative change in enthalpy.

There are two ways for us to use enthalpy – we can use it to predict what ΔH will be for a given reaction, and, once we know that, we can use it to predict ΔH depending on the amounts of reactants (this is where stoichiometry re-enters the picture ☺). Chemistry problems involving enthalpy changes are similar to stoichiometry problems. The amount of heat released or absorbed during a reaction depends on the number of moles of the reactants involved. The reaction of a mole of CaO with water released 65.2 kJ of heat, so the reaction of 2 moles of CaO with water would release twice as much heat, or 130.4 kJ

PRACTICE PROBLEMS:

1) The combustion of methane, CH_4, releases 890.4 kJ/mol. That is, when one mole of methane is burned, 890.4 kJ are given off to the surroundings. This means that the products have 890.4 kJ *less* than the reactants. Thus, ΔH for the reaction = - 890.4 kJ. *A negative symbol for ΔH indicates an exothermic reaction.*

$$CH_4\ (g) + 2\ O_2\ (g) \rightarrow CO_2\ (g) + 2\ H_2O\ (l);\ \Delta H = -\ 890.4\ kJ$$

   a) How much energy is given off when 2.00 mol of CH_4 are burned? [-1780 kJ]
   b) How much energy is released when 22.4g of CH_4 are burned? [-1240 kJ]
   c) If you were to attempt to make 45.0g of methane from CO_2 and H_2O (with O_2 also being made), how much energy would be required? [2.50×10^3 kJ]

2) What is the change in enthalpy when 9.75 g of aluminum reacts with excess ammonium nitrate (NH_4NO_3) according to the equation: [-367 kJ]

$$2Al + 3NH_4NO_3 \rightarrow 3N_2 + 6\ H_2O + Al_2O_3 \qquad \Delta H = -2030kJ$$

3) How much enthalpy/heat is transferred when 0.5113 g of ammonium (NH_3) reacts with excess oxygen according to the following equation: [-6.79 kJ]

$$4NH_3 + 5O_2 \rightarrow 4NO + 6H_2O \qquad \Delta H = -905.4kJ$$

4) According to the following reactions, would the burning of 5.50 g of methane (CH_4) or propane (C_3H_8) release more heat? [methane, with -305 kJ]

$$C_3H_8(g) + 5O_2(g) \rightarrow 3CO_2(g) + 4H_2O(g) \qquad \Delta H = -2043\ kJ$$

$$CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(g) \qquad \Delta H = -890.\ kJ$$

CHALLENGE PROBLEM:

How much heat is transferred when 147 g of NO_2 reacts with 100. g H2O according to the following equation:

$$3NO_2 + H_2O \rightarrow 2HNO_3 + NO \qquad \Delta H = -138\ kJ$$