**Heat of Reaction Problems** Name_____ Period_____

The heat of reaction is the quantity of energy released or absorbed as heat during a chemical reaction. Some reactions are exothermic and release heat on the product side of the reaction and some reactions are endothermic and must absorb heat on the reactant side of the reaction to complete the reaction.

We can predict if it is exothermic or endothermic by looking at the thermochemical equation. The thermochemical equation is the balanced reaction written with the quantity of heat released or absorbed during the reaction.

Exothermic Reaction: $2H_{2(g)} + O_{2(g)} \rightarrow 2H_2O_{(g)}$ **+ 483.6 kJ**

The reverse reaction can be an Endothermic Reaction: $2H_2O_{(g)}$ **+ 483.6 kJ** $\rightarrow 2H_{2(g)} + O_{2(g)}$

The amount of energy absorbed or lost by a system as heat is the enthalpy change. The Change in Enthalpy (ΔH) can be found by determining the total enthalpy for the reactants subtracted from the total enthalpy of the products.

$$\Delta H = H_{products} - H_{reactants}$$

Exothermic Reaction: $2H_{2(g)} + O_{2(g)} \rightarrow 2H_2O_{(g)}$ **ΔH = - 483.6 kJ**

Endothermic Reaction: $2H_2O_{(g)} \rightarrow 2H_{2(g)} + O_{2(g)}$ **ΔH =+ 483.6 kJ**

In order to determine the "change in enthalpy" (*AKA ΔH*) for a reaction, we must first determine how much heat was absorbed or released to create each compound. The ***molar heat of formation*** ($\Delta H_f^0$) is the energy released or absorbed as heat when one mole of a compound if formed by a combination of its elements. We can look up these values in a table.

| **Molar Heat of Formation for Selected Chemicals and Compounds ($\Delta H_f^0$)** | | | | | |
|---|---|---|---|---|---|
| **Al, Fe (Elements in their natural state, do not form compounds, therefore their $\Delta H_f^0$ is 0)** | | | | | |
| **$Cl_2$, $H_2$, $O_2$ (Diatomic molecules bond to themselves in their natural state, do not form compounds, therefore their $\Delta H_f^0$ is 0)** | | | | | |
| **$CaCO_3$** | **-1207 kJ/mol** | **$CCl_4$** | **-135 kJ/mol** | **$C_2H_5OH_{(l)}$** | **-228 kJ/mol** |
| **$CO_2$** | **-394 kJ/mol** | **KCl** | **-436 kJ/mol** | **$H_2O_{(g)}$** | **-242 kJ/mol** |
| **CaO** | **-635 kJ/mol** | **$KClO_3$** | **-391 kJ/mol** | **$H_2O_{(l)}$** | **-286 kJ/mol** |
| **$CH_4$** | **-75 kJ/mol** | **$C_2H_2$** | **+227 kJ/mol** | | |
| **$Fe_3O_{4(s)}$** | **-1121 kJ/mol** | **$Al_2O_{3(s)}$** | **-1670 kJ/mol** | | |
| | | | | | |

1. Aluminum reacts with Iron(IV)Oxide in the following balanced reaction. What is the Change in Enthalpy (ΔH) for the reaction and is it exothermic or endothermic?

$$8\ Al_{(s)} + 3\ Fe_3O_{4(s)} \rightarrow 4\ Al_2O_{3(s)} + 9\ Fe_{(s)}$$

2. Calcium carbonate decomposes at high temperature to form carbon dioxide and calcium oxide:

$$CaCO_3 \rightarrow CO_2 + CaO$$

Given the heats of formation in the chart above, determine the heat of reaction and tell if the reaction is exothermic or endothermic.

3. Carbon tetrachloride can be formed by reacting chlorine with methane:

$$CH_4 + 2\ Cl_2 \rightarrow CCl_4 + 2\ H_2$$

Given the heats of formation in the chart above, determine the heat of reaction and tell if the reaction is exothermic or endothermic.

4. When potassium chloride reacts with oxygen under the right conditions, potassium chlorate is formed:

$$2\ KCl + 3\ O_2 \rightarrow 2KClO_3$$

Given the heats of formation in the chart above, determine the heat of reaction and tell if the reaction is exothermic or endothermic.

5. The reaction below represents the combustion of acetylene

$$2C_2H_{2(g)} + 5O_{2(g)} \text{ —> } 4CO_{2(g)} + 2H_2O_{(g)}$$

Given the heats of formation in the chart above, determine the heat of reaction and tell if the reaction is exothermic or endothermic.

6. Ethanol is burned in the presence of oxygen to produce carbon dioxide and water.

$$C_2H_5OH_{(l)} + 3\ O_{2(g)} \rightarrow 2\ CO_{2(g)} + 3\ H_2O_{(l)}$$

Given the heats of formation in the chart above, determine the heat of reaction and tell if the reaction is exothermic or endothermic.