CHEMICAL HEAT

Classic

Hess's Law

Date:

1. How is ΔH for a reaction related to ΔH for the reverse reaction?

2. Consider the following thermo chemical equation:

   $2NH_{3(g)} + 3Cl_{2(g)} \Rightarrow N_{2(g)} + 6HCl_{(g)} + 110$ kcal.

   Determine the enthalpy change, in kcal, in each of the following reactions.

   a) $N_{2\,(g)} + 6HCl_{(g)} \Rightarrow 2NH_{3\,(g)} + 3Cl_{2\,(g)}$

   b) $NH_{3\,(g)} + 3/2\ Cl_{2\,(g)} \Rightarrow \frac{1}{2}\ N_{2\,(g)} + 3HCl_{(g)}$

   c) $4NH_{3\,(g)} + 6Cl_{2\,(g)} \Rightarrow 2N_{2\,(g)} + 12HCl_{(g)}$

   d) $\frac{1}{2}\ N_{2\,(g)} + 3HCl_{(g)} \Rightarrow NH_{3\,(g)} + 3/2\ Cl_{2(g)}$

3. Given the heats of reaction:

   $\frac{1}{2}\ N_{2\,(g)} + \frac{1}{2}\ O_{2\,(g)} \Rightarrow NO_{(g)}$ $\Delta H = +22$ kcal

   $\frac{1}{2}\ N_{2\,(g)} + O_{2\,(g)} \Rightarrow NO_{2\,(g)}$ $\Delta H = +8$ kcal

   Determine the heat of the reaction:

   $NO_{(g)} + \frac{1}{2}\ O_{2\,(g)} \Rightarrow NO_{2\,(g)}$

4. Given the following:

   $4NO_{(g)} \Rightarrow 2N_2O_{(g)} + O_{2(g)}$ $\Delta H = -33$ kcal

   $2NO_{(g)} + O_{2(g)} \Rightarrow 2NO_{2(g)}$ $\Delta H = -17$ kcal

   Calculate ΔH for the reaction:

   $2N_2O_{\,(g)} + 3O_{2\,(g)} \Rightarrow 4NO_{2\,(g)}$

5. The standard heats of combustion of $C_6H_{6\,(l)}$, $H_2O_{\,(g)}$, and $C_6H_{12\,(l)}$ are –782 kcal/mol, –68 kcal/mol, and –938 kcal/mol respectively, when the products of combustion are $CO_{2(g)}$, $H_2O_{(l)}$, calculate $\Delta H°$ for the reaction.

   $C_6H_{12\,(l)} \Rightarrow C_6H_{6\,(l)} + 3H_{2\,(g)}$

6. $4CO_{(g)} + 8H_{2(g)} \Rightarrow 3CH_{4(g)} + CO_{2(g)} + 2H_2O_{(l)}$ $\Delta H=?$

   Determine ΔH of the reaction by using the following data

   $C_{(graphite)} + \frac{1}{2}O_{2(g)} \Rightarrow CO_{(g)}$ $\Delta H = -26$ kcal

   $CO_{(g)} + \frac{1}{2}O_{2(g)} \Rightarrow CO_{2(g)}$ $\Delta H = -67$ kcal

   $H_{2(g)} + \frac{1}{2}O_{2(g)} \Rightarrow H_2O_{(l)}$ $\Delta H = -68$ kcal

   $C_{(graphite)} + 2H_{2(g)} \Rightarrow CH_{4(g)}$ $\Delta H = -18$ kcal

7. Given these reactions and their ΔH values.

   $COCl_{2(g)} + 4NH_{3(g)} \Rightarrow CO(NH_2)_{2(s)} + 2NH_4Cl_{(s)} + 80$ kcal

   $COCl_{2(g)} + H_2O_{(l)} \Rightarrow CO_{2\,(g)} + 2HCl_{(g)}$ $\Delta H = -34$ kcal

   $NH_{3(g)} + HCl_{(g)} \Rightarrow NH_4Cl_{(g)}$ $\Delta H = -22$ kcal

   Calculate ΔH for the reaction:

   $CO(NH_2)_{2\,(s)} + H_2O_{(l)} \Rightarrow CO_{2(g)} + 2NH_{3\,(g)}$

8. From the following data

   $Fe_3O_{4(s)} + CO_{\,(g)} \Rightarrow 3FeO_{(s)} + CO_{2\,(g)}$ $\Delta H = +9$ kcal

   $2Fe_3O_{4(s)} + CO_{2(g)} \Rightarrow 3Fe_2O_{3\,(s)} + CO_{(g)}$ $\Delta H = +14$ kcal

   $Fe_2O_{3(s)} + 3CO_{(g)} \Rightarrow 2Fe_{(s)} + 3CO_{2\,(g)}$ $\Delta H = -7$ kcal

   Calculate the enthalpy change for the reaction:

   $FeO_{\,(s)} + CO_{\,(g)} \Rightarrow Fe_{\,(s)} + CO_{2\,(g)}$

9. From the following heats of combustion,

   $4NH_{3\,(g)} + 5O_{2\,(g)} \Rightarrow 4NO_{\,(g)} + 6H_2O_{\,(l)}$ $\Delta H° = -278$ kcal

   $4NH_{3\,(g)} + 3O_{2\,(g)} \Rightarrow 2N_{2\,(g)} + 6H_2O_{\,(l)}$ $\Delta H° = -366$ kcal

   Calculate the standard heat of formation of $NO_{\,(g)}$.

10. The heats of combustion per mole of 1.3 – butadiene, $C_4H_{6(g)}$, normal butane, $C_4H_{10(g)}$, and $H_{2\,(g)}$ are –608, –689, –68 kcal/mol respectively. Use these data to calculate the heat of hydrogenation of 1.3 – butadiene to normal butane.

    $C_4H_{6(g)} + 2H_{2(g)} \Rightarrow C_4H_{10(g)}$