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Chemistry 30

Unit 1: Energy Changes in Chemical Reactions

Assignment 3: Sections 2-4 to 2-7

1. When iron rusts in air, the following reaction occurs:

   $4\ Fe_{(s)} + 3\ O_{2\ (g)} \rightarrow 2\ Fe_2O_{3\ (s)}\ \Delta H = -1643\ kJ$

   What is the heat of formation of Fe_2O_3?

   (hint: what is the heat of formation reaction for Fe_2O_3? How does this reaction compare to the reaction given in the question?)

2. The equation for the decomposition of mercury(II) oxide is as follows:

   $2\ HgO_{(s)} + 182\ kJ \rightarrow 2\ Hg_{(l)} + O_{2\ (g)}$

   Determine ΔH_f for $HgO_{(s)}$?

   (hint: What does ΔH_f mean? What would be the overall equation associated with ΔH_f?)

3. Using a table of thermochemical data, calculate $\Delta H°$ for the following reactions. Show your work.

   a. $CO\ (g) + ½\ O_2\ (g) \rightarrow CO_2\ (g)$

   b. $CH_4\ (g) + 2\ O_2\ (g) \rightarrow CO_2\ (g) + 2\ H_2O\ (g)$

c. $CS_2(g) + 2\ H_2O(l) \rightarrow CO_2(g) + 2\ H_2S(g)$

4. Calculate ΔH° for the process:

$$2\ Al(s) + Fe_2O_3\ (s) \rightarrow Al_2O_3\ (s) + 2\ Fe(s)$$

Given that ΔH_f° of Fe_2O_3 = -813.0 kJ/mole and ΔH_f° of Al_2O_3 is -1,655.0 kJ/mol

5. The standard heats of formation for CH_4, $CHCl_3$ and HCl are -74.8, -132, -92.0 kJ/mole, respectively. Use this information to calculate the heat of reaction for the following reaction:

$$CH_4 + 3\ Cl_2 \rightarrow CHCl_3 + 3\ HCl$$

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6. The standard heat of formation, ΔH_f, for C_2H_4 is +52.3 kJ/mol. If C_2H_4 (ethylene) reacts with H_2 to produce C_2H_6 (ethane) according to the following equation:

$$C_2H_4 + H_2 \rightarrow C_2H_6 \quad \Delta H = -137 \text{ kJ}$$

what is the heat of formation of C_2H_6?

(**Hint**: Solve this question without looking up ΔH_f° for C_2H_6 in the Table of Thermochemical Data, although you may want to in order to check your answer. Solve this using the standard formula, $\Delta H_{reaction} = \Sigma \Delta H_{products} - \Sigma \Delta_{reactants}$. However, this time you know $\Delta H_{reaction}$ and need to solve for a substance on the product side of the equation.)

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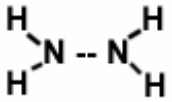
7. Using bond enthalpies, calculate ΔH for the following reaction:

   $N_2 + 2\ H_2 \rightarrow N_2H_4$

   The structural formulas for all reaction participants are shown here:

   $N \equiv N + 2\ H—H \rightarrow$ 

8. The energy from the combustion of hydrazine, N_2H_4, is used to power rockets into space in the reaction:

   $N_2H_4\ (g) + O_2\ (g) \rightarrow N_2\ (g) + 2\ H_2O\ (l) \qquad \Delta H° = -627.6\ kJ$

   How many kilograms of hydrazine would be necessary to produce 1.0×10^8 kJ of energy?

   Hint: **One mole** of N_2H_4 produces 627.6 kJ of energy. How many moles (and then grams) are required to produce 1.0×10^8 kJ of energy?