Determine ΔH for each of the following three reactions.

478. The following reaction is used to make CaO from limestone:

$$CaCO_3(s) \rightarrow CaO(s) + CO_2(g)$$

479. The following reaction represents the oxidation of FeO to Fe_2O_3:

$$2FeO(s) + O_2(g) \rightarrow Fe_2O_3(s)$$

480. The following reaction of ammonia and hydrogen fluoride produces ammonium fluoride:

$$NH_3(g) + HF(g) \rightarrow NH_4F(s)$$

481. Calculate the free energy change, ΔG, for the combustion of hydrogen sulfide according to the following chemical equation. Assume reactants and products are at 25°C:

$$H_2S(g) + O_2(g) \rightarrow H_2O(l) + SO_2(g)$$

$\Delta H_{reaction} = -562.1$ kJ/mol

$\Delta S_{reaction} = -0.09278$ kJ/mol•K

482. Calculate the free energy change for the decomposition of sodium chlorate. Assume reactants and products are at 25°C:

$$NaClO_3(s) \rightarrow NaCl(s) + O_2(g)$$

$\Delta H_{reaction} = -19.1$ kJ/mol

$\Delta S_{reaction} = -0.1768$ kJ/mol•K

483. Calculate the free energy change for the combustion of 1 mol of ethane. Assume reactants and products are at 25°C:

$$C_2H_6(g) + O_2(g) \rightarrow 2CO_2(g) + 3H_2O(l)$$

$\Delta H_{reaction} = -1561$ kJ/mol

$\Delta S_{reaction} = -0.4084$ kJ/mol•K

Mixed Review

484. Calculate ΔH for the reaction of fluorine with water:

$$F_2(g) + H_2O(l) \rightarrow 2HF(g) + O_2(g)$$

485. Calculate ΔH for the reaction of calcium oxide and sulfur trioxide:

$$CaO(s) + SO_3(g) \rightarrow CaSO_4(s)$$

Use the following equations and data:

$$H_2O(l) + SO_3(g) \rightarrow H_2SO_4(l)$$

$\Delta H = -132.5$ kJ/mol

$$H_2SO_4(l) + Ca(s) \rightarrow CaSO_4(s) + H_2(g)$$

$\Delta H = -602.5$ kJ/mol

$$Ca(s) + O_2(g) \rightarrow CaO(s)$$

$\Delta H = -634.9$ kJ/mol

$$H_2(g) + O_2(g) \rightarrow H_2O(l)$$

$\Delta H = -285.8$ kJ/mol

486. Calculate ΔH for the reaction of sodium oxide with sulfur dioxide:

$$Na_2O(s) + SO_2(g) \rightarrow Na_2SO_3(s)$$

487. Use enthalpies of combustion to calculate ΔH for the oxidation of 1-butanol to make butanoic acid:

$$C_4H_9OH(l) + O_2(g) \rightarrow C_3H_7COOH(l) + H_2O(l)$$

Combustion of butanol:

$$C_4H_9OH(l) + 6O_2(g) \rightarrow 4CO_2(g) + 5H_2O(l)$$

$\Delta H_c = -2675.9$ kJ/mol

Combustion of butanoic acid:

$$C_3H_7COOH(l) + 5O_2(g) \rightarrow 4CO_2(g) + 4H_2O(l)$$

$\Delta H_c = -2183.6$ kJ/mol

488. Determine the free energy change for the reduction of CuO with hydrogen. Products and reactants are at 25°C.

$$CuO(s) + H_2(g) \rightarrow Cu(s) + H_2O(l)$$

$\Delta H = -128.5$ kJ/mol

$\Delta S = -70.1$ J/mol•K

489. Calculate the enthalpy change at 25°C for the reaction of sodium iodide and chlorine. Use only the data given.

$$NaI(s) + Cl_2(g) \rightarrow NaCl(s) + I_2(l)$$

$\Delta S = -79.9$ J/mol•K

$\Delta G = -98.0$ kJ/mol

490. The element bromine can be produced by the reaction of hydrogen bromide and manganese(IV) oxide:

$$4HBr(g) + MnO_2(s) \rightarrow MnBr_2(s) + 2H_2O(l) + Br_2(l)$$

ΔH for the reaction is -291.3 kJ/mol at 25°C. Use this value and the following values of ΔH_f^0 to calculate ΔH_f^0 of $MnBr_2(s)$.

$\Delta H_{f_{HBr}}^0 = -36.29$ kJ/mol

$\Delta H_{f_{MnO_2}}^0 = -520.0$ kJ/mol

$\Delta H_{f_{H_2O}}^0 = -285.8$ kJ/mol

$\Delta H_{f_{Br_2}}^0 = 0.00$ kJ/mol

491. Calculate the change in entropy, ΔS, at 25°C for the reaction of calcium carbide with water to produce acetylene gas:

$$CaC_2(s) + 2H_2O(l) \rightarrow C_2H_2(g) + Ca(OH)_2(s)$$

$\Delta G = -147.7$ kJ/mol

$\Delta H = -125.6$ kJ/mol

492. Calculate the free energy change for the explosive decomposition of ammonium nitrate at 25°C. Note that H_2O is a gas in this reaction:

$$NH_4NO_3(s) \rightarrow N_2O(g) + 2H_2O(g)$$

$\Delta S = 446.4$ J/mol•K

493. In locations where natural gas, which is mostly methane, is not available, many people burn propane, which is delivered by truck and stored in a tank under pressure.

a. Write the chemical equations for the complete combustion of 1 mol of methane, CH_4, and 1 mol of propane, C_3H_8.

b. Calculate the enthalpy change for each reaction to determine the amount of energy as heat evolved by burning 1 mol of each fuel.

c. Using the molar enthalpies of combustion you calculated, determine the energy output per kilogram of each fuel. Which fuel yields more energy per unit mass?

494. The hydration of acetylene to form acetaldehyde is shown in the following equation:

$$C_2H_2(g) + H_2O(l) \rightarrow CH_3CHO(l)$$