Thermochemistry 4

1. **A. Determine the heat of reaction for the oxidation of iron given the enthalpies of the reactions below.**

$4\ Fe(s) + 3\ O_2(g) \rightarrow 2\ Fe_2O_3(s)$

Use these reactions:

$2\ Fe(s) + 6\ H_2O(\ell) \rightarrow 2\ Fe(OH)_3(s) + 3\ H_2(g)$ $\quad \Delta H = 321.8\ kJ$) × 2

$4\ Fe + 12\ H_2O \rightarrow 4\ Fe(OH)_3 + 6\ H_2$

643.6

$2\ H_2(g) + O_2(g) \rightarrow 2\ H_2O(\ell)$ $\quad \Delta H = -571.7\ kJ$) × 3

$6\ H_2 + 3\ O_2 \rightarrow 6\ H_2O$

-1715.1

$Fe_2O_3(s) + 3\ H_2O(\ell) \rightarrow 2\ Fe(OH)_3(s)$ $\quad \Delta H = 288.6\ kJ$) × -2

$4\ Fe(OH)_3 \rightarrow 2\ Fe_2O_3 + 6\ H_2O$

-577.2

$\Delta H_{rxn} = -1649\ kJ$

2. What mass of propane ($C_3H_{8(g)}$) must be burned in order to heat 1.00 kg of water at 20.0 °C to water at 88.0°C? Assume all of the heat for the combustion is transferred to the water.

$q_{rxn} = -q_{water}$

$q_{rxn} = -(1000\,g)(4.184\,J/g^{\circ})(68.0\,^{\circ})$

$q_{rxn} = -284500\,J = -284.5\,kJ$ needed

$$\underset{-105}{1}\,C_3H_{8(g)} + \underset{0}{5}\,O_{2(g)} \rightarrow \underset{-393.5}{3}\,CO_{2(g)} + \underset{-241.8\ kJ/mol}{4}\,H_2O_{(g)}$$

$\Delta H = 3(-393.5) + 4(-241.8) - (-105) = -2042.7\,kJ/mol$

$$\frac{-284.5\,kJ}{-2042.7\,kJ} \left| \frac{1\,mol\ C_3H_8}{1\,mol\ C_3H_8} \right| \frac{44.09\,g\ C_3H_8}{1\,mol\ C_3H_8} = 6.1407\,g$$

(if 100% burned was effective)

↓

often not the case.

6.14 g

3. Using a table of standard heats of formation, calculate the heat of reaction for the complete combustion of acetylene, C_2H_2.

$$2\ C_2H_{2(g)} + 5O_{2(g)} \rightarrow 4\ CO_{2(g)} + 2\ H_2O_{(g)}$$

$$\Delta H^\circ_{rxn} = \left[4(-393.5) + 2(-241.8)\right] - \left[2(227)\right]$$

$$\Delta H^\circ_{rxn} = -2512\ kJ \quad \text{(as balanced above)}$$

4. Consider the reaction of 40.0 g of CS_2 were reacted with excess chlorine gas in a calorimeter with a heat capacity of 4.89 kJ/C° (this value includes any water contained in the calorimeter). What change in temperature could be expected?

$$CS_{2(g)} + 3Cl_{2(g)} \rightarrow S_2Cl_{2(g)} + CCl_{4(g)} \qquad \Delta H = -232\ kJ$$

$M_m = 76.14\ g/mol$

$$\frac{40.0\ g \mid 1\ mol\ CS_2 \mid -232\ kJ}{\mid 76.14\ g \mid 1\ mol\ CS_2} = -121.88\ kJ$$

$$q_{rxn} = -121{,}880\ J$$

$$-q_{rxn} = q_{calorimeter}$$

$$-q_{rxn} = H_c \Delta T$$

$$-(-121{,}880\ J) = \left(4890\ J/C^\circ\right)\Delta T$$

$$\boxed{\Delta T = +24.9 C^\circ}$$