Problem Set Chapter 8

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1. Calculate the final temperature of a 25[g] piece of Al $\left(c = .89\left[\frac{\text{J}}{\text{g}\,^\circ\text{C}}\right]\right)$ that is initially at 25[$^\circ$ C] when 2.3[kJ] of heat is applied

$$\begin{aligned} 2300 &= .89 \cdot 25 \cdot (T_f - 25) \\ T_f &= \frac{2300}{.89 \cdot 25} + 25 \\ &= 128.37[^\circ\text{C}] \end{aligned} \tag{1}$$

2. A 25[g] sample of Fe ($c = .89\left[\frac{\text{J}}{\text{g}\,^\circ\text{C}}\right]$) at 22[$^\circ$ C] is placed in 75[g] of water $\left(c = 4.184\left[\frac{\text{J}}{\text{g}\,^\circ\text{C}}\right]\right)$. The final temperature of the mixture is 34[$^\circ$ C]. What was the initial temperature of the water?

$$\begin{aligned} q &= .89 \cdot 25 \cdot (34 - 22) \\ &= 267[\text{J}] \\ 267 &= 4.184 \cdot 75 \cdot (T_o - 34) \\ T_o &= 34.85[^\circ\text{C}] \end{aligned} \tag{2}$$

3. The enthalpy change for the combustion of CH_4 is -891[kJ]. Calculate the amount of energy given off if you start with 52[g] of oxygen. Calculate the change of energy for the formation of 125[g] of water.

$$\begin{aligned} \text{CH}_4 + 2\,\text{O}_2 &\longrightarrow 2\,\text{H}_2\text{O} + \text{CO}_2 \\ E_{\text{O}_2} &= 52 \cdot \frac{1}{32} \cdot \frac{-891}{2} \\ &= -723.94[\text{J}] \\ E_{\text{H}_2\text{O}} &= 125 \cdot \frac{1}{18} \cdot \frac{-891}{2} \\ &= -3093.8[\text{J}] \end{aligned} \tag{3}$$

4. Upon heating, 1[g] of $KClO_3$ decomposes to KCl and $KClO_4$, evolving 350[J] of heat. Calculate ΔH if you start with 55[g] of $KClO_3$. Calculate ΔH for the formation of 35[g] of $KClO_4$.

$$
\begin{aligned}
4\,KClO_3 &\longrightarrow KCl + 3\,KClO_4 \\
\Delta H_{KClO3} &= 55 \cdot -350 \\
&= -19.25[\text{kJ}] \\
\frac{35}{139} &= .2518[\text{mol}_{KClO_4}] \\
\frac{4}{3} \cdot .2518 &= .3357[\text{mol}_{KClO_3}] \\
.3357 \cdot 123 &= 41.29[\text{g}_{KClO_3}] \\
\Delta H_{KClO4} &= 41.29 \cdot -350 \\
&= -14.45[\text{kJ}]
\end{aligned}
\tag{4}
$$

5. Calculate ΔH for the reaction of $2\,PCl_5 + 2\,H_2O \longrightarrow 2\,POCl_3 + 4\,HCl$

Given:
$$
\begin{aligned}
2\,POCl_3 &\longrightarrow 2\,P + 3\,Cl_2 + O_2 \quad & \Delta H &= 559[\text{kJ}] \\
4\,HCl &\longrightarrow 2\,H_2 + 2\,Cl_2 & \Delta H &= 185[\text{kJ}] \\
2\,PCl_5 &\longrightarrow 2\,P + 5\,Cl_2 & \Delta H &= 375[\text{kJ}] \\
2\,H_2 + O_2 &\longrightarrow 2\,H_2O & \Delta H &= 241[\text{kJ}]
\end{aligned}
$$

$$
\begin{aligned}
2\,P + 3\,Cl_2 + O_2 &\longrightarrow 2\,POCl_3 \\
\Delta H &= -559[\text{kJ}] \\
2\,H_2 + 2\,Cl_2 &\longrightarrow 4\,HCl \\
\Delta H &= -185[\text{kJ}] \\
\hline
2\,P + 5\,Cl_2 + 2\,H_2 + O_2 &\longrightarrow 2\,POCl_3 + 4\,HCl \\
\Delta H &= -744[\text{kJ}] \\
2\,PCl_5 &\longrightarrow 2\,P + 5\,Cl_2 \\
\Delta H &= 375[\text{kJ}] \\
\hline
2\,PCl_5 + 2\,H_2 + O_2 &\longrightarrow 2\,POCl_3 + 4\,HCl \\
\Delta H &= -369[\text{kJ}] \\
2\,H_2O &\longrightarrow 2\,H_2 + O_2 \\
\Delta H &= -241[\text{kJ}] \\
\hline
2\,PCl_5 + 2\,H_2O &\longrightarrow 2\,POCl_3 + 4\,HCl \\
\Delta H &= -610[\text{kJ}]
\end{aligned}
\tag{5}
$$