15.12 First we balance the equation:

$$PCl_5(g) + 4\,H_2O(l) \longrightarrow 5\,HCl(aq) + H_3PO_4(aq)$$

$$\Delta G^\circ_r = 5(-131.23\ kJ \cdot mol^{-1}) + (-1142.54\ kJ \cdot mol^{-1}) - [(-305.0\ kJ \cdot mol^{-1}) + 4(-237.13\ kJ \cdot mol^{-1})]$$

$$= -545.17\ kJ \cdot mol^{-1}$$

The reaction is spontaneous.

15.42 Because there is no data available for the free energy of formation of HClO, we must turn to the electrochemical data in Appendix 2B. The appropriate half-reactions are

$$Cl_2 + 2\,e^- \longrightarrow 2\,Cl^- \qquad E^\circ = +1.36\ V$$

$$Cl_2 + 2\,H_2O \longrightarrow 2\,HClO + 2\,H^+ + 2\,e^- \qquad E^\circ = -1.63\ V$$

$$2\,Cl_2 + 2\,H_2O \longrightarrow 2\,HClO + 2\,H^+ + 2\,Cl^- \qquad E^\circ = -0.27\ V$$

The E° will be the same for the reaction balanced as

$$Cl_2 + H_2O \longrightarrow HClO + H^+ + Cl^- \qquad E^\circ = -0.27\ V$$

but n will be $1\ e^-$ rather than $2\ e^-$ as in the previous equation.

ΔG°_r can now be calculated from $\Delta G^\circ_r = -nFE^\circ$

$$\Delta G^\circ_r = -(1)(96\,485\ J \cdot V^{-1} \cdot mol^{-1})(-0.27\ V) = +26\ kJ \cdot mol^{-1}$$

(b) The equilibrium constant can be calculated from $\Delta G^\circ_r = -RT \ln K$

$$K = e^{-\frac{\Delta G^\circ_r}{RT}} = e^{-\frac{26\,000\ J \cdot mol^{-1}}{(8.314\ J \cdot K^{-1} \cdot mol^{-1})(298\ K)}} \cong 2.8 \times 10^{-5}$$

15.84 The balanced chemical equation is:

$$2\,K_2MnF_6 + 4\,SbF_5 \rightarrow 4\,KSbF_6 + 2\,MnF_3 + F_2$$

The amount, in moles, of F_2 produced is found by:

$$\frac{125\ g\ K_2MnF_6}{247.14\ g \cdot mol^{-1}}\left(\frac{1\ mol\ F_2}{2\ mol\ K_2MnF_6}\right) = 0.253\ mol\ F_2$$

The volume of this amount of fluorine gas is:

$$V = \frac{nRT}{P} = \frac{(0.253\ mol)(0.08206\ L \cdot atm \cdot K^{-1} \cdot mol^{-1})(298\ K)}{1\ atm}$$

$$= 6.18\ L$$