PROBLEM 13.50

KNOWN: $C_4H_{10}(g)$ reacts completely with air. The reactants and products are at 25°C, 1 atm.

FIND: Determine the enthalpy of combustion for (a) $H_2O(g)$ in the products, (b) $H_2O(\ell)$ in the products, express each in kJ per kmol of fuel and kJ per kg of fuel.

ASSUMPTIONS: (1) 3.76 moles of N_2 accompany each mole of O_2 in the air. N_2 is inert. (2) Combustion is with the theoretical amount of air. (3) The combustion air and the combustion products can be modeled as ideal gases.

ANALYSIS: Complete combustion of C_4H_{10} with the theoretical amount of air is described by

$$C_4H_{10} + 6.5(O_2 + 3.76N_2) \rightarrow 4CO_2 + 5H_2O + 24.44N_2$$

The enthalpy of combustion is

$$\bar{h}_{RP} = 4\bar{h}_{CO_2} + 5\bar{h}_{H_2O} - \bar{h}_{C_4H_{10}} - 6.5\bar{h}_{O_2}$$

Since the reactants and products are at 25°C, 1 atm this reduces simply to

$$\bar{h}^\circ_{RP} = 4(\bar{h}^\circ_f)_{CO_2} + 5(\bar{h}^\circ_f)_{H_2O} - (\bar{h}^\circ_f)_{C_4H_{10}}$$

(a) H_2O is a vapor. Using data from Table A-25

$$\bar{h}^\circ_{RP} = 4(-393,520) + 5(-241,820) - (-126,150) = -2.657\times10^6 \text{ kJ/kmol}(C_4H_{10})$$

For C_4H_{10}, $M = 58.12$, so

$$h^\circ_{RP} = -\frac{2.657\times10^6}{58.12} = -45,716 \frac{kJ}{kg}$$

(a)

(b) H_2O is a liquid. Using data from Table A-25

$$\bar{h}^\circ_{RP} = 4(-393,520) + 5(-285,830) - (126,150) = -2.877\times10^6 \text{ kJ/kmol}(C_4H_{10})$$

and

$$h^\circ_{RP} = -\frac{2.877\times10^6}{58.12} = -49,501 \frac{kJ}{kg}$$

(b)