

COMBINATION PROBLEM 1



$$Q = mc\Delta T$$

$$Q = 30\,000 \text{ g} \times 4.184 \frac{\text{J}}{\text{g}^\circ\text{C}} (23.94 - 20.00)^\circ\text{C}$$

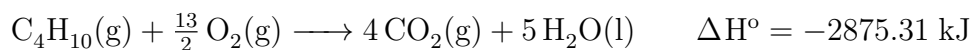
$$Q = 494548.8 \text{ J}$$

$$Q = 494.55 \text{ kJ}$$

$$\frac{494.55 \text{ kJ}}{10 \text{ g C}_4\text{H}_{10}} \times \frac{58.14 \text{ g C}_4\text{H}_{10}}{1 \text{ mol C}_4\text{H}_{10}} = \frac{2875.31 \text{ kJ}}{1 \text{ mol C}_4\text{H}_{10}}$$

$$\Delta H = -Q$$

$$\Delta H = -2875.31 \text{ kJ/1 mol C}_4\text{H}_{10}$$



$$\begin{aligned} \Delta H^\circ &= [4\Delta H_{\text{CO}_2(\text{g})}^\circ + 5\Delta H_{\text{H}_2\text{O}(\text{l})}^\circ] - [\Delta H_{\text{C}_4\text{H}_{10}(\text{g})}^\circ + \frac{13}{2}\Delta H_{\text{O}_2(\text{g})}^\circ] \\ -2875.31 \text{ kJ} &= [4(-393.5 \text{ kJ}) + 5(-285.8 \text{ kJ})] - [\Delta H_{\text{C}_4\text{H}_{10}}^\circ + \frac{13}{2}(0)] \end{aligned}$$

$$\Delta H_{\text{C}_4\text{H}_{10}(\text{g})}^\circ = -3003.0 \text{ kJ} + 2875.31 \text{ kJ}$$

$$\Delta H_{\text{C}_4\text{H}_{10}(\text{g})}^\circ = -127.69 \text{ kJ}$$

Please note that the textbook value (pg 799) for the heat of formation of C_4H_{10} is -125.6 kJ. This is definitely close enough!

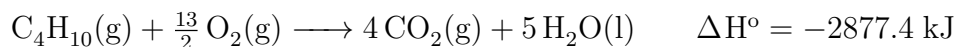
COMBINATION PROBLEM 2



$$\Delta H^\circ = [4\Delta H^\circ_{\text{CO}_2(\text{g})} + 5\Delta H^\circ_{\text{H}_2\text{O}(\text{l})}] - [\Delta H^\circ_{\text{C}_4\text{H}_{10}(\text{g})} + \frac{13}{2}\Delta H^\circ_{\text{O}_2(\text{g})}]$$

$$\Delta H^\circ = [4(-393.5 \text{ kJ}) + 5(-285.8 \text{ kJ})] - [-125.6 \text{ kJ} + \frac{13}{2}(0)]$$

$$\Delta H^\circ = -2877.4 \text{ kJ}$$



$$Q = -\Delta H$$

$$Q = 2877.4 \text{ kJ/mol C}_4\text{H}_{10}$$

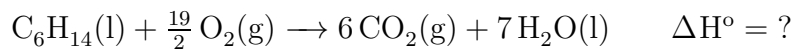
$$25.00 \text{ g C}_4\text{H}_{10} \times \frac{1 \text{ mol C}_4\text{H}_{10}}{58.14 \text{ g C}_4\text{H}_{10}} \times \frac{2877.4 \text{ kJ}}{1 \text{ mol C}_4\text{H}_{10}} \times \frac{1000 \text{ J}}{1 \text{ kJ}} = 1237272 \text{ J}$$

$$\Delta T = \frac{Q}{mc}$$

$$\Delta T = \frac{1237272 \text{ J}}{50\,000 \text{ g} \times 4.184 \frac{\text{J}}{\text{g}^\circ\text{C}}}$$

$$\Delta T = 5.914 \text{ }^\circ\text{C}$$

COMBINATION PROBLEM 3



$$Q = mc\Delta T$$

$$Q = 25\,000 \text{ g} \times 4.184 \frac{\text{J}}{\text{g}^\circ\text{C}} (31.925 - 25.000)^\circ\text{C}$$

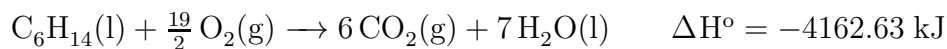
$$Q = 724355 \text{ J}$$

$$Q = 724.36 \text{ kJ}$$

$$\frac{724.36 \text{ kJ}}{15 \text{ g C}_6\text{H}_{14}} \times \frac{86.20 \text{ g C}_6\text{H}_{14}}{1 \text{ mol C}_6\text{H}_{14}} = \frac{4162.63 \text{ kJ}}{1 \text{ mol C}_6\text{H}_{14}}$$

$$\Delta\text{H} = -Q$$

$$\Delta\text{H} = -4162.63 \text{ kJ}/1 \text{ mol C}_6\text{H}_{14}$$



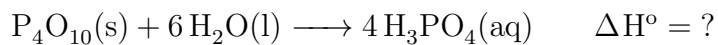
$$\begin{aligned} \Delta\text{H}^\circ &= [6\Delta\text{H}_{\text{CO}_2(\text{g})}^\circ + 7\Delta\text{H}_{\text{H}_2\text{O}(\text{l})}^\circ] - [\Delta\text{H}_{\text{C}_6\text{H}_{14}(\text{l})}^\circ + \frac{19}{2} \Delta\text{H}_{\text{O}_2(\text{g})}^\circ] \\ -4162.63 \text{ kJ} &= [6(-393.5 \text{ kJ}) + 7(-285.8 \text{ kJ})] - [\Delta\text{H}_{\text{C}_6\text{H}_{14}}^\circ + \frac{19}{2} (0)] \end{aligned}$$

$$\Delta\text{H}_{\text{C}_6\text{H}_{14}(\text{l})}^\circ = -4361.6 \text{ kJ} + 4162.63 \text{ kJ}$$

$$\Delta\text{H}_{\text{C}_6\text{H}_{14}(\text{l})}^\circ = -198.97 \text{ kJ}$$

Please note that the textbook value (pg 799) for the heat of formation of C_6H_{14} is -198.7 kJ. This is definitely close enough!

COMBINATION PROBLEM 4



$$Q = mc\Delta T$$

$$Q = 1\,000 \text{ g} \times 4.184 \frac{\text{J}}{\text{g}^\circ\text{C}} (19.93 - 15.03)^\circ\text{C}$$

$$Q = 20501.6 \text{ J}$$

$$Q = 20.502 \text{ kJ}$$

$$\frac{20.502 \text{ kJ}}{13.5 \text{ g P}_4\text{O}_{10}} \times \frac{283.88 \text{ g P}_4\text{O}_{10}}{1 \text{ mol P}_4\text{O}_{10}} = \frac{431.11 \text{ kJ}}{1 \text{ mol P}_4\text{O}_{10}}$$

$$\Delta H = -Q$$

$$\Delta H = -431.11 \text{ kJ}/1 \text{ mol P}_4\text{O}_{10}$$



$$\Delta H^\circ = [4\Delta H_{\text{H}_3\text{PO}_4(\text{aq})}^\circ] - [\Delta H_{\text{P}_4\text{O}_{10}}^\circ + 6\Delta H_{\text{H}_2\text{O}(\text{l})}^\circ]$$

$$-431.11 \text{ kJ} = [4\Delta H_{\text{H}_3\text{PO}_4(\text{aq})}^\circ] - [(-3012.48 \text{ kJ}) + 6(-285.77 \text{ kJ})]$$

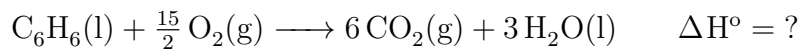
$$-4\Delta H_{\text{H}_3\text{PO}_4(\text{aq})}^\circ = 4727.10 \text{ kJ} + 431.11 \text{ kJ}$$

$$\Delta H_{\text{H}_3\text{PO}_4(\text{aq})}^\circ = -1289.55 \text{ kJ}$$

For comparison to the answer given in the question, convert to kcal

$$-1289.55 \text{ kJ} \times \frac{1 \text{ kcal}}{4.184 \text{ kJ}} = -308.21 \text{ kcal}$$

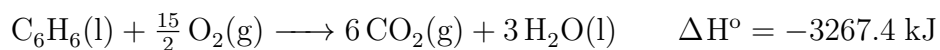
COMBINATION PROBLEM 5



$$\Delta \text{H}^\circ = [6\Delta \text{H}_{\text{CO}_2(\text{g})}^\circ + 3\Delta \text{H}_{\text{H}_2\text{O}(\text{l})}^\circ] - [\Delta \text{H}_{\text{C}_6\text{H}_6(\text{g})}^\circ + \frac{15}{2}\Delta \text{H}_{\text{O}_2(\text{g})}^\circ]$$

$$\Delta \text{H}^\circ = [6(-393.5 \text{ kJ}) + 3(-285.8 \text{ kJ})] - [+49.0 \text{ kJ} + \frac{15}{2}(0)]$$

$$\Delta \text{H}^\circ = -3267.4 \text{ kJ}$$

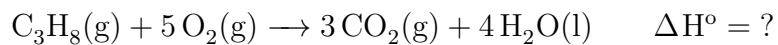


$$Q = -\Delta \text{H}$$

$$Q = 3267.4 \text{ kJ/mol C}_6\text{H}_6$$

$$100 \text{ kJ} \times \frac{1 \text{ mol C}_6\text{H}_6}{3267.4 \text{ kJ}} \times \frac{78.12 \text{ g C}_6\text{H}_6}{1 \text{ mol C}_6\text{H}_6} = 2.391 \text{ g C}_6\text{H}_6$$

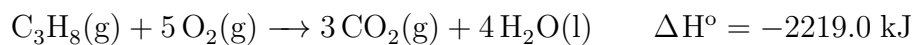
COMBINATION PROBLEM 6



$$\Delta H^\circ = [3\Delta H_{\text{CO}_2(\text{g})}^\circ + 4\Delta H_{\text{H}_2\text{O}(\text{l})}^\circ] - [\Delta H_{\text{C}_3\text{H}_8(\text{g})}^\circ + 5\Delta H_{\text{O}_2(\text{g})}^\circ]$$

$$\Delta H^\circ = [3(-393.5 \text{ kJ}) + 4(-285.8 \text{ kJ})] - [-104.7 \text{ kJ} + 5(0)]$$

$$\Delta H^\circ = -2219.0 \text{ kJ}$$



$$Q = -\Delta H$$

$$Q = 2219.0 \text{ kJ/mol C}_3\text{H}_8$$

$$Q = mc\Delta T$$

$$Q = 160\,000 \text{ g} \times 4.184 \frac{\text{J}}{\text{g}^\circ\text{C}} \times (52.00 - 15.00)^\circ\text{C}$$

$$Q = 24769280 \text{ J}$$

$$Q = 24769.28 \text{ kJ}$$

$$24769.28 \text{ kJ} \times \frac{1 \text{ mol C}_3\text{H}_8}{2219.0 \text{ kJ}} \times \frac{44.11 \text{ g C}_3\text{H}_8}{1 \text{ mol C}_3\text{H}_8} = 492.37 \text{ g C}_3\text{H}_8$$

COMBINATION PROBLEM 7



$$Q = mc\Delta T$$

$$Q = 50\,000 \text{ g} \times 4.184 \frac{\text{J}}{\text{g}^\circ\text{C}} \times 11.469^\circ\text{C}$$

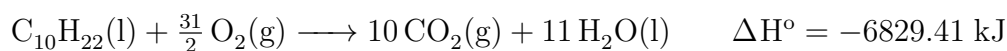
$$Q = 2399314.8 \text{ J}$$

$$Q = 2399.31 \text{ kJ}$$

$$\frac{2399.31 \text{ kJ}}{50 \text{ g C}_{10}\text{H}_{22}} \times \frac{142.32 \text{ g C}_{10}\text{H}_{22}}{1 \text{ mol C}_{10}\text{H}_{22}} = \frac{6829.41 \text{ kJ}}{1 \text{ mol C}_{10}\text{H}_{22}}$$

$$\Delta H = -Q$$

$$\Delta H = -6829.41 \text{ kJ/1 mol C}_{10}\text{H}_{22}$$



$$\begin{aligned} \Delta H^\circ &= [10\Delta H^\circ_{\text{CO}_2(\text{g})} + 11\Delta H^\circ_{\text{H}_2\text{O}(\text{l})}] - [\Delta H^\circ_{\text{C}_{10}\text{H}_{22}(\text{g})} + \frac{31}{2}\Delta H^\circ_{\text{O}_2(\text{g})}] \\ -6829.41 \text{ kJ} &= [10(-393.5 \text{ kJ}) + 11(-285.8 \text{ kJ})] - [\Delta H^\circ_{\text{C}_{10}\text{H}_{22}} + \frac{31}{2}(0)] \end{aligned}$$

$$\Delta H^\circ_{\text{C}_{10}\text{H}_{22}(\text{g})} = -7078.8 \text{ kJ} + 6829.41 \text{ kJ}$$

$$\Delta H^\circ_{\text{C}_{10}\text{H}_{22}(\text{g})} = -249.39 \text{ kJ}$$

COMBINATION PROBLEM 8



$$Q = mc\Delta T$$

$$Q = 8\,000 \text{ g} \times 4.184 \frac{\text{J}}{\text{g}^\circ\text{C}} (40 - 20)^\circ\text{C}$$

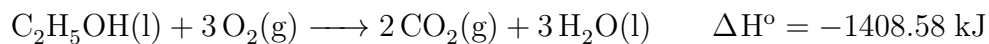
$$Q = 669\,440 \text{ J}$$

$$Q = 669.44 \text{ kJ}$$

$$\frac{669.44 \text{ kJ}}{21.9 \text{ g C}_2\text{H}_5\text{OH}} \times \frac{46.08 \text{ g C}_2\text{H}_5\text{OH}}{1 \text{ mol C}_2\text{H}_5\text{OH}} = \frac{1408.58 \text{ kJ}}{1 \text{ mol C}_2\text{H}_5\text{OH}}$$

$$\Delta H = -Q$$

$$\Delta H = -1408.58 \text{ kJ/1 mol C}_2\text{H}_5\text{OH}$$



$$\Delta H^\circ = [2\Delta H_{\text{CO}_2(g)}^\circ + 3\Delta H_{\text{H}_2\text{O}(l)}^\circ] - [\Delta H_{\text{C}_2\text{H}_5\text{OH}(g)}^\circ + 3\Delta H_{\text{O}_2(g)}^\circ]$$

$$-1408.58 \text{ kJ} = [2(-393.5 \text{ kJ}) + 3(-285.8 \text{ kJ})] - [\Delta H_{\text{C}_2\text{H}_5\text{OH}}^\circ + 3(0)]$$

$$\Delta H_{\text{C}_2\text{H}_5\text{OH}(g)}^\circ = -1644.4 \text{ kJ} + 1408.58 \text{ kJ}$$

$$\Delta H_{\text{C}_2\text{H}_5\text{OH}(g)}^\circ = -235.82 \text{ kJ}$$

Please note that the textbook value (pg 799) for the heat of formation of $\text{C}_2\text{H}_5\text{OH}(l)$ is -235.2 kJ. This is definitely close enough!