

AP CHEMISTRY

TOPIC 9: THERMODYNAMICS, PART D, EXAMPLES, PART II

Day 111:

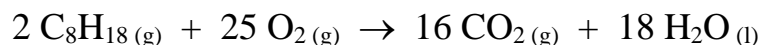
- Free Energy and Equilibrium

Example #2: Octane gas, C_8H_{18} , is used in gasoline. Use the data below to answer the following questions about the combustion of octane gas.

Substance	ΔH_f^0 (kJ mol ⁻¹)	S^0 (J mol ⁻¹ K ⁻¹)
$C_8H_{18}(g)$	-208.4	345.3
$O_2(g)$	0	205.1
$CO_2(g)$	-393.5	213.7
$H_2O(l)$	-285.8	188.8

Use the data above to answer the questions that follow. Assume all reactions take place at 25 °C.

- a) Write a complete balanced chemical equation for the combustion of octane. Assume that carbon dioxide and water are the only products.



- b) Calculate the standard enthalpy change, ΔH^0 , for the combustion of one mole of octane gas.

$$\Delta H^0_{rxn} = \sum \Delta H_f^0 \text{ (products)} - \sum \Delta H_f^0 \text{ (reactants)}$$

$$\Delta H^0_{comb} = \left[16 \left(\frac{-393.5 \text{ kJ}}{\text{mol}} \right) + 18 \left(\frac{-285.8 \text{ kJ}}{\text{mol}} \right) \right] - \left[2 \left(\frac{-208.4 \text{ kJ}}{\text{mol}} \right) + 25 \left(\frac{0 \text{ kJ}}{\text{mol}} \right) \right] = -11023.6 \frac{\text{kJ}}{\text{mol}}$$

Typically the question wants to know the enthalpy change for one mole of octane gas: Therefore,

$$\Delta H^0_{comb} = -11023.6 \frac{\text{kJ}}{\text{mol}} \text{ for 2 moles of } C_8H_{18}(g)$$

$$\text{For 1 mole of } C_8H_{18}(g): \frac{-11023.6 \frac{\text{kJ}}{\text{mol}}}{2} = -5511.8 \frac{\text{kJ}}{\text{mol}}$$

- c) Calculate the standard entropy change, ΔS^0 , for the combustion of one mole of octane gas.

$$\Delta S^0_{rxn} = \sum \Delta S^0 \text{ (products)} - \sum \Delta S^0 \text{ (reactants)}$$

$$\Delta S^0_{rxn} = \left[16 \left(\frac{213.7 \text{ J}}{\text{mol} \cdot \text{K}} \right) + 18 \left(\frac{188.8 \text{ J}}{\text{mol} \cdot \text{K}} \right) \right] - \left[2 \left(\frac{345.3 \text{ J}}{\text{mol} \cdot \text{K}} \right) + 25 \left(\frac{205.1 \text{ J}}{\text{mol} \cdot \text{K}} \right) \right] = +999.5 \frac{\text{J}}{\text{mol} \cdot \text{K}}$$

$$\text{For 1 mole of } C_8H_{18}(g): \frac{+999.5 \frac{\text{J}}{\text{mol} \cdot \text{K}}}{2} = +499.75 \frac{\text{J}}{\text{mol} \cdot \text{K}}$$

d) Determine the value of ΔG^0 for the reaction.

$$\Delta G = \Delta H - T\Delta S$$

$$\text{Convert (J to kJ): } \Delta S = \left(+ 499.75 \frac{\text{J}}{\text{mol} \cdot \text{K}} \right) \left(\frac{1 \text{ kJ}}{1000 \text{ J}} \right) = + 0.49975 \frac{\text{kJ}}{\text{mol} \cdot \text{K}}$$

$$\Delta G = \left(-5511.8 \frac{\text{kJ}}{\text{mol}} \right) - (298 \text{ K}) \left(+ 0.49975 \frac{\text{kJ}}{\text{mol} \cdot \text{K}} \right) = - 5661 \frac{\text{kJ}}{\text{mol}}$$