

Chemistry 192

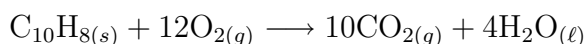
Recitation Session Questions

March 19, 2018

Solutions

1. The standard enthalpy of combustion of solid naphthalene at 298K (C_{10}H_8) is $\Delta_{r,m}H^\circ = -5156.1 \text{ kJ mol}^{-1}$. Given $\Delta_{f,m}H^\circ(\text{H}_2\text{O}_{(\ell)}) = -285.8 \text{ kJ mol}^{-1}$ and $\Delta_{f,m}H^\circ(\text{CO}_{2(g)}) = -393.5 \text{ kJ mol}^{-1}$, calculate the standard enthalpy of formation of solid naphthalene.

Answer:



$$\begin{aligned}\Delta_{r,m}H^\circ &= 10\Delta_{f,m}H^\circ(\text{CO}_{2(g)}) + 4\Delta_{f,m}H^\circ(\text{H}_2\text{O}_{(\ell)}) - \Delta_{f,m}H^\circ(\text{C}_{10}\text{H}_{8(s)}) - 12\Delta_{f,m}H^\circ(\text{O}_{2(g)}) \\ -5156.1 \text{ kJ mol}^{-1} &= 10(-393.5 \text{ kJ mol}^{-1}) + 4(-285.8 \text{ kJ mol}^{-1}) - 12(0) - \Delta_{f,m}H^\circ(\text{C}_{10}\text{H}_{8(s)}) \\ \Delta_{f,m}H^\circ(\text{C}_{10}\text{H}_{8(s)}) &= 77.9 \text{ kJ mol}^{-1}\end{aligned}$$

2. The standard Gibbs free energy of combustion of solid naphthalene at 298K (C_{10}H_8) is $\Delta_{r,m}G^\circ = -5094.1 \text{ kJ mol}^{-1}$. Given $\Delta_{f,m}G^\circ(\text{H}_2\text{O}_{(\ell)}) = -237.1 \text{ kJ mol}^{-1}$ and $\Delta_{f,m}G^\circ(\text{CO}_{2(g)}) = -394.4 \text{ kJ mol}^{-1}$, calculate the standard Gibbs free energy of formation of solid naphthalene.

Answer:

$$\begin{aligned}\Delta_{r,m}G^\circ &= 10\Delta_{f,m}G^\circ(\text{CO}_{2(g)}) + 4\Delta_{f,m}G^\circ(\text{H}_2\text{O}_{(\ell)}) - \Delta_{f,m}G^\circ(\text{C}_{10}\text{H}_{8(s)}) - 12\Delta_{f,m}G^\circ(\text{O}_{2(g)}) \\ -5094.1 \text{ kJ mol}^{-1} &= 10(-394.4 \text{ kJ mol}^{-1}) + 4(-237.1 \text{ kJ mol}^{-1}) - 12(0) - \Delta_{f,m}G^\circ(\text{C}_{10}\text{H}_{8(s)}) \\ \Delta_{f,m}G^\circ(\text{C}_{10}\text{H}_{8(s)}) &= 201.7 \text{ kJ mol}^{-1}\end{aligned}$$

3. Given the standard, molar entropies at 298K $S^\circ(\text{CO}_{2(g)}) = 213.7 \text{ J mol}^{-1}\text{K}^{-1}$, $S^\circ(\text{H}_2\text{O}_{(\ell)}) = 69.91 \text{ J mol}^{-1}\text{K}^{-1}$, and $S^\circ(\text{naphthalene}) = 167.5 \text{ J mol}^{-1}\text{K}^{-1}$, calculate the standard third-law entropy of oxygen gas.

Answer:

Let the subscript c represent combustion. Then

$$\begin{aligned}\Delta_{c,m}G^\circ &= \Delta_{c,m}H^\circ - T\Delta_{c,m}S^\circ \\ -5094.1 \times 10^3 \text{ J mol}^{-1} &= -5156.1 \times 10^3 \text{ J mol}^{-1} - (298. \text{ K})\Delta_{c,m}S^\circ\end{aligned}$$

$$\begin{aligned}
\Delta_{c,m}S^\circ &= -208. \text{ J mol}^{-1}\text{K}^{-1} \\
&= 10S_m^\circ(\text{CO}_{2(g)}) + 4S_m^\circ(\text{H}_2\text{O}_{(\ell)}) - S_m^\circ(\text{C}_{10}\text{H}_{8(s)}) - 12S_m^\circ(\text{O}_{2(g)}) \\
&= 10(213.7 \text{ J mol}^{-1}\text{K}^{-1}) + 4(69.91 \text{ J mol}^{-1}\text{K}^{-1}) - 167.5 \text{ J mol}^{-1}\text{K}^{-1} - 12S_m^\circ(\text{O}_{2(g)}) \\
S_m^\circ &= 205. \text{ J mol}^{-1}\text{K}^{-1}
\end{aligned}$$