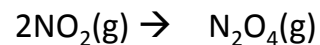


More on Gibbs Energy



- What do you predict for the sign of ΔS ?
- $\Delta S^\circ = -175.8 \text{ J/K.mol}$
- $\Delta H^\circ = -57.2 \text{ kJ/mol}$
- What is ΔG° ?
 - A. -4.8 kJ/mol
 - B. $5.2 \times 10^4 \text{ kJ/mol}$
 - C. 4.8 kJ/mol
 - D. -29 kJ/mol



- What do you predict for the sign of ΔS ?
- $\Delta S^\circ = -175.8 \text{ J/K.mol}$
- $\Delta H^\circ = -57.2 \text{ kJ/mol}$
- What is ΔG° ?
- $\Delta G^\circ = \Delta H^\circ - T\Delta S^\circ$
- $= -57.2 \text{ kJ/mol} - 298\text{K}(-175.8 \text{ J/K.mol} \times 1\text{kJ}/1000\text{J})$
- $= -4.8 \text{ kJ/mol}$

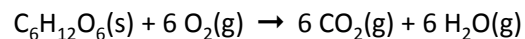
Careful of
the units!

At what temperature will the reaction

- When $\Delta G^\circ = 0$

When $\Delta G = 0$

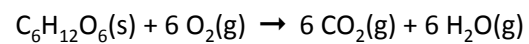
- The system is at **equilibrium**
 - (for example a phase change)
- So $\Delta G = \Delta H - T\Delta S$ becomes
- $0 = \Delta H - T\Delta S$
- $\Delta H = T\Delta S$
- For water boiling $\Delta H^\circ = 40.65 \text{ kJ/mol}$
- What is ΔS° ?
- $\Delta S^\circ = 109 \text{ J/K.mol}$



This is a combustion reaction: what do you predict the sign of enthalpy change will ΔH be?

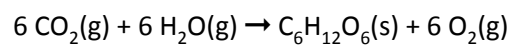
- A. +
- B. -
- C. 0
- D. Don't know

What about ΔS ? ΔG ?



ΔH is $-$, ΔS is $+$, and ΔG is $-$ (at all temperatures)

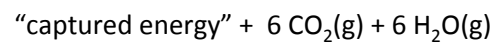
This reaction is always favorable!



ΔH is $+$, ΔS is $-$, and ΔG is $+$ (at all temperatures)

This reaction is NEVER favorable!
But it happens – (how?)

From the
sun

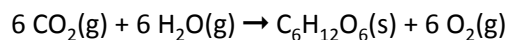


Dissipated as
"heat" not
useful

As we will see next semester, the

Calculating ΔH° , ΔS° , and ΔG° from standard thermodynamic formation data.

- There are tables of these values that can be used to calculate overall changes for a reaction
- ΔH°_f (standard heat of formation)
 - Enthalpy change when a substance is formed from its elements in their standard states.
- For any reaction
- $\Delta H^\circ_f = \sum \Delta H^\circ_f \text{ products} - \sum \Delta H^\circ_f \text{ reactants}$



- ΔH°_f for:
- $\text{CO}_2(\text{g}) = -394 \text{ kJ/mol}$
- $\text{H}_2\text{O}(\text{g}) = -242 \text{ kJ/mol}$
- $\text{C}_6\text{H}_{12}\text{O}_6(\text{s}) = -1271 \text{ kJ/mol}$
- $\text{O}_2(\text{g}) = 0 \text{ kJ/mol}$ (element in its standard state)

Third Law of Thermodynamics

- The entropy of a perfect crystal at 0K is 0
- This allows us to calculate actual entropies of materials (as opposed to changes in entropy)
- $S^\circ \text{H}_2\text{O(l)} = 69.9 \text{ J/K.mol}$, $\text{H}_2\text{O(g)} = 189 \text{ J/K.mol}$
- And
- $\Delta S^\circ_r = \sum S^\circ \text{ products} - \sum S^\circ \text{ reactants}$
