

CH16

I. Amplitude of entropy S:

- $S_g \gg S_l > S_s$
- for a reaction, the side with larger total # of mole of gas molecule has larger S
- complicated molecule (more atoms) has higher S

II. Spontaneous process: $\Delta S_{\text{universe}} > 0$, $\Delta G < 0$

- $\Delta S_{\text{universe}} = \Delta S_{\text{system}} + \Delta S_{\text{surrounding}} = \Delta S_{\text{system}} - \Delta H/T \rightarrow -T \Delta S_{\text{universe}} = -T \Delta S_{\text{system}} + \Delta H$
- $\Delta G = \Delta H - T\Delta S$
- calculate ΔG , ΔH , and ΔS for a chemical reaction

III. ΔG , ΔG^0 , K and Q:

- $\Delta G^0 = -RT \ln K$
- $\Delta G = \Delta G^0 + RT \ln Q = -RT \ln K + RT \ln Q$
- $\Delta G^0 > 0$, $K < 1$; $\Delta G^0 = 0$, $K = 1$; $\Delta G^0 < 0$, $K > 1$;
- $\Delta G > 0$, $Q > K$; $\Delta G = 0$, $Q = K$; $\Delta G < 0$, $Q < K$;

CH16**16.I**

1. Which one has larger entropy?
 1 mole of HCl(g) vs 1 mole of **HBr(g)**; $\text{CH}_3\text{OH(l)} + 3/2 \text{O}_2(\text{g}) \Rightarrow \text{CO}_2(\text{g}) + 2 \text{H}_2\text{O}(\text{g})$; 1 mole of NO₂(g) vs 1 mole of **N₂O₄(g)**

16.II

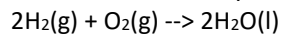
2. For the combustion of acetylene at 298.15 K,
 $2 \text{C}_2\text{H}_2(\text{g}) + 5 \text{O}_2(\text{g}) \rightarrow 4 \text{CO}_2(\text{g}) + 2 \text{H}_2\text{O}(\text{g})$
 calculate $\Delta S^\circ(\text{universe})$ given $\Delta S^\circ(\text{system}) = -194.6 \text{ J/K}$ and $\Delta H^\circ(\text{system}) = -2511.2 \text{ kJ}$. [**+8228.0 J/K**] can you do 1mole C₂H₂?

3. Use the table below to answer the question that follows.

Thermodynamic Quantities for Selected Substances at 298.15 K (25 °C)

Substance	ΔH°_f (kJ/mol)	ΔG°_f (kJ/mol)	S (J/K-mol)
Carbon			
C (s, diamond)	1.88	2.84	2.43
C (s, graphite)	0	0	5.69
C ₂ H ₂ (g)	226.7	209.2	200.8
C ₂ H ₄ (g)	52.30	68.11	219.4
C ₂ H ₆ (g)	-84.68	-32.89	229.5
CO (g)	-110.5	-137.2	197.9
CO ₂ (g)	-393.5	-394.4	213.6
Hydrogen			
H ₂ (g)	0	0	130.58
Oxygen			
O ₂ (g)	0	0	205.0
H ₂ O (l)	-285.83	-237.13	69.91

The combustion of hydrogen in the presence of excess oxygen yields water:



The value of ΔS° for this reaction is ____ J/K mol. [**-326.3**]

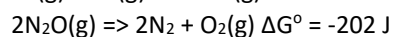
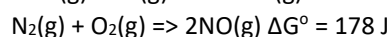
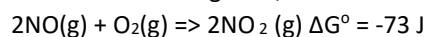
The value of ΔG° for this reaction is ____ KJ/ mol. [**-474.26**]

The value of ΔH° for this reaction is ____ KJ/ mol. [**-571.66**]

4. A particular reaction has a ΔH° value of -10 kJ and ΔS° of -500 J/mol K at 298 K. Assuming that ΔH° and ΔS° hardly change with temperature, determine the temperature in $^\circ\text{C}$ at which the spontaneity of this reaction changes. [-253 $^\circ\text{C}$]

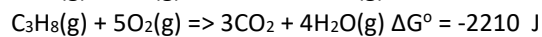
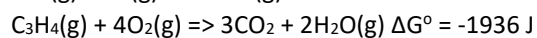
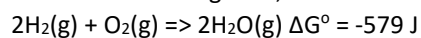
5. A particular reaction has a ΔH° value of 3 kJ and ΔS° of 10 J/mol K at 298 K. Assuming that ΔH° and ΔS° hardly change with temperature, determine the temperature in $^\circ\text{C}$ at which the spontaneity of this reaction changes. [27]

6. Given the following data,



Determine ΔG_r° for $\text{N}_2\text{O}(\text{g}) + \text{NO}_2(\text{g}) \Rightarrow 3\text{NO}(\text{g})$ [113.5 J]

7. Given the following data,



Determine ΔG_r° for $\text{C}_3\text{H}_4(\text{g}) + 2\text{H}_2(\text{g}) \Rightarrow \text{C}_3\text{H}_8(\text{g})$ [-305 J]

16.III

8. At 250 K, ΔG° equals 4.157 kJ for the reaction, $\text{N}_2(\text{g}) + 3 \text{H}_2(\text{g}) \rightleftharpoons 2 \text{NH}_3(\text{g})$. Calculate the value of $\ln K$ for the reaction at this temperature to one decimal place. [-2]
9. The value of ΔG° for the reaction, $\text{N}_2(\text{g}) + 3 \text{H}_2(\text{g}) \rightleftharpoons 2 \text{NH}_3(\text{g})$ is -32.90 kJ at 298 K. Calculate the value of ΔG in kJ at 298 K if the partial pressures of N_2 , H_2 and NH_3 are 0.5, 1, and 2 atm respectively. [-27.748 kJ]
10. What is ΔG for $\text{N}_2 + 3\text{H}_2 \rightleftharpoons 2\text{NH}_3$ under the given conditions at 400K? Will the reaction go toward products, reactants or is it at equilibrium? $P_{\text{N}_2} = 4.2 \text{ bar}$, $P_{\text{H}_2} = 1.8 \text{ bar}$, $P_{\text{NH}_3} = 21 \text{ bar}$, $K(400\text{K}) = 41$. [-21.9 kJ]