

Conceptual Questions:

1. What is the second law of thermodynamics?
 2. For any process, what are the four possible combinations of ΔH and ΔS ? Which of these correspond to always spontaneous or always non-spontaneous reactions? Under what conditions would the last two combinations be spontaneous?
 3. What is the third law of thermodynamics?
 4. For a gas phase reaction, how do you determine the sign of ΔS° ? How about for a phase change?
 5. For a liquid, would you expect ΔS_{fusion} or $\Delta S_{\text{evaporation}}$ to be larger? Why?
 6. True or False: High temperatures are favorable to a reaction both kinetically and thermodynamically? Explain.
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1. Calculate the standard entropy change for the following reaction at 25 °C:
$$2\text{Al}(s) + 3\text{ZnO}(s) \rightarrow \text{Al}_2\text{O}_3(s) + 3\text{Zn}(s)$$
 2. A certain reaction has $\Delta H^\circ = -19.5 \text{ kJ}$ and $\Delta S^\circ = 42.7 \text{ J K}^{-1}$.
 - a. Calculate ΔG° for the reaction.
 - b. Is the reaction spontaneous under standard conditions?
 - 3a. Using the data given below, calculate ΔG° for the reaction: $2\text{SO}_2(g) + \text{O}_2(g) \rightarrow 2\text{SO}_3(g)$
 - 3b. Is this reaction spontaneous as written under standard conditions?
 - 3c. What is the equilibrium constant K for this reaction?
 4. Calculate ΔG° for the process: $\text{C}(\text{diamond}) \leftrightarrow \text{C}(\text{graphite})$
Is the formation of graphite from diamond favored at 25°C? If so, why is it that diamonds do not become graphite on standing?
-

5. Consider the formation of a dimeric protein: $2\text{P} \rightarrow \text{P}_2$. At 25°C, we have $\Delta H^\circ = 17 \text{ kJ/mol}$ and $\Delta S^\circ = 65 \text{ J/mol}\cdot\text{K}$. Is the dimerization favored at this temperature? What would be the effect of lowering the temperature?
6. The equilibrium constant K_P for the reaction below is 5.62×10^{35} at 25°C. What is ΔG°_f for COCl_2 at 25°C? Would you predict the ΔS for this reaction to be positive or negative? $\text{CO}(g) + \text{Cl}_2(g) \leftrightarrow \text{COCl}_2(g)$

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7. What is ΔG° for the reaction below at 25°C?



8. Consider the following reaction:



Calculate ΔG at 25°C for the reaction if the partial pressures of the initial mixture are

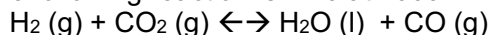
$P_{\text{PCl}_5} = 0.0029 \text{ atm}$, $P_{\text{PCl}_3} = 0.27 \text{ atm}$, and $P_{\text{Cl}_2} = 0.40 \text{ atm}$.

9. Which of the following reactions would be spontaneous at 25°C? If either is non-spontaneous, at what temperature would it become spontaneous?

a. $\Delta H = 10.5 \text{ kJ/mol}$, $\Delta S = 30 \text{ J/molK}$

b. $\Delta H = 1.8 \text{ kJ/mol}$, $\Delta S = -113 \text{ J/molK}$

10. The equilibrium constant (K_P) for the following reaction is 4.40 at 2000K.



a. Calculate ΔG° for the reaction at 2000K

b. Calculate ΔG for the reaction when $P_{\text{H}_2} = 0.78 \text{ atm}$, $P_{\text{H}_2\text{O}} = 0.66 \text{ atm}$, and $P_{\text{CO}} = 1.20 \text{ atm}$.

	ΔH_f°	S°	ΔG_f°
Al (s)		28.3 J/K•mol	
Al ₂ O ₃ (s)		50.99 J/K•mol	
ZnO (s)		43.9 J/K•mol	
Zn (s)		41.6 J/K•mol	
SO ₂ (g)			-300.4 kJ mol ⁻¹
O ₂ (g)			0 kJ mol ⁻¹
SO ₃ (g)			-370.4 kJ mol ⁻¹
C (diamond)	1.90 kJ mol ⁻¹	2.4 J/K•mol	
C (graphite)	0 kJ mol ⁻¹	5.69 J/K•mol	
Cl ₂ (g)	0 kJ mol ⁻¹	223 J/K•mol	0 kJ mol ⁻¹
CH ₄ (g)	-74.85 kJ mol ⁻¹	186.2 J/K•mol	-50.8 kJ mol ⁻¹
CH ₃ Cl (g)	-83.68 kJ mol ⁻¹	234.36 J/K•mol	---
CH ₂ Cl ₂ (g)	-95.52 kJ mol ⁻¹	270.28 J/K•mol	---
HCl (g)	-92.3 kJ mol ⁻¹	187 J/K•mol	-95.27 kJ mol ⁻¹

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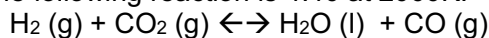
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