

Study Guide

Chapter 17

Name: _____

Date: _____ Per: _____

- Describe the
 - 1st Law of Thermodynamics _____

 - 2nd Law of Thermodynamics _____

 - 3rd Law of Thermodynamics _____

- Define a spontaneous process: _____

 - In a system at equilibrium, which reaction (forward or reverse) is spontaneous? _____
 - The spontaneity of a process may depend on _____
- Define:
 - Entropy: _____
 - Isothermal: _____
 - PV Work: _____
 - Microstate: _____
- The entropy of the universe is constantly _____.
- Indicate if each of the following processes results in an increase or decrease in entropy.

a. Boiling water _____	f. Burning of wood _____
b. Freezing water _____	g. Mixing two gases _____
c. Condensation _____	h. Gas expanding in a container _____
d. Sublimation _____	i. Dissolving CO ₂ in water _____
e. Dissolving a solid _____	j. Combustion of hydrogen _____
- What does a positive value of ΔS indicate? _____
- Indicate if ΔS is positive (+) or negative (-) for each of the following reactions.

a. $2\text{NO}(\text{g}) + \text{O}_2(\text{g}) \rightarrow 2\text{NO}_2(\text{g})$ _____	f. $\text{NH}_4\text{Cl}(\text{s}) \rightarrow \text{NH}_3(\text{g}) + \text{HCl}(\text{g})$ _____
b. $\text{H}_2\text{O}(\text{l}) \rightarrow \text{H}_2\text{O}(\text{g})$ _____	g. $\text{Mg}(\text{s}) + \text{Cl}_2(\text{g}) \rightarrow \text{MgCl}_2(\text{s})$ _____
c. $\text{PbCl}_2(\text{s}) \rightarrow \text{Pb}^{2+}(\text{aq}) + 2\text{Cl}^{-}(\text{aq})$ _____	h. $\text{C}_2\text{H}_4(\text{g}) + \text{H}_2(\text{g}) \rightarrow \text{C}_2\text{H}_6(\text{g})$ _____
d. $2\text{N}_2(\text{g}) + 3\text{H}_2(\text{g}) \rightarrow 2\text{NH}_3(\text{g})$ _____	i. $\text{C}_3\text{H}_8(\text{g}) + 5\text{O}_2(\text{g}) \rightarrow 3\text{CO}_2(\text{g}) + 4\text{H}_2\text{O}(\text{g})$ _____
e. $2\text{C}(\text{s}) + \text{O}_2(\text{g}) \rightarrow 2\text{CO}_2(\text{g})$ _____	j. $2\text{SO}_2(\text{g}) + \text{O}_2(\text{g}) \rightarrow 2\text{SO}_3(\text{g})$ _____
- Rank each of the following lists in order of increasing entropy.

a. H ₂ O (s) _____	H ₂ O (l) _____	H ₂ O (g) _____	H ₂ S (g) _____	H ₂ S (l) _____
b. H ₂ (g) _____	C ₂ H ₆ (g) _____	C ₂ H ₂ (g) _____	CH ₄ (g) _____	C ₂ H ₄ (g) _____
- The formula for calculating the change in entropy of a system for an isothermal process is _____.
- The formula for calculating the change in entropy of the surrounding of an isothermal process is _____.
- For the reaction, $2\text{C}_4\text{H}_{10}(\text{g}) + 13\text{O}_2(\text{g}) \rightarrow 8\text{CO}_2(\text{g}) + 10\text{H}_2\text{O}(\text{g})$, ΔH° is -125 kJ/mol and ΔS° is +253 J/K · mol. Describe the spontaneity of this reaction. _____

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12. For a reaction to be spontaneous under standard conditions at all temperatures, the signs of ΔH° and ΔS° must be _____ and _____, respectively.
13. If $\Delta G^\circ < 0$, K _____. If $\Delta G^\circ > 0$, K _____. If $\Delta G^\circ = 0$, K _____.
14. Consider the reaction: $\text{NH}_3(\text{g}) + \text{HCl}(\text{g}) \rightarrow \text{NH}_4\text{Cl}(\text{s})$. Given the following table of thermodynamic data, determine the temperature (in $^\circ\text{C}$) above which the reaction is nonspontaneous. (345 $^\circ\text{C}$)

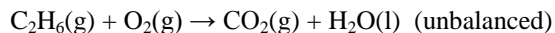
Substance	ΔH_f° (kJ/mol)	S° (J/mol \cdot K)
NH_3 (g)	-46.19	192.5
HCl (g)	-92.30	186.69
NH_4Cl (s)	-314.4	94.6

15. Consider the reaction: $\text{FeO}(\text{s}) + \text{Fe}(\text{s}) + \text{O}_2(\text{g}) \rightarrow \text{Fe}_2\text{O}_3(\text{s})$. Given the following table of thermodynamic data at 298 K, find the value of K at 25 $^\circ\text{C}$. (7.1×10^{85})

Substance	ΔH_f° (kJ/mol)	S° (J/K \cdot mol)
FeO (s)	-271.9	60.75
Fe (s)	0	27.15
O_2 (g)	0	205.0
Fe_2O_3 (s)	-822.16	89.96

16. Find the temperature (in K) above which a reaction with a ΔH of 123.0 kJ/mol and a ΔS of 90.00 J/K \cdot mol becomes spontaneous. (1367 K)

17. Calculate ΔG° (in kJ/mol) for the following reaction at 1 atm and 25 $^\circ\text{C}$. (-2934.0)



$$\Delta H_f^\circ \text{C}_2\text{H}_6(\text{g}) = -84.7 \text{ kJ/mol}; \quad S^\circ \text{C}_2\text{H}_6(\text{g}) = 229.5 \text{ J/K} \cdot \text{mol};$$

$$\Delta H_f^\circ \text{CO}_2(\text{g}) = -393.5 \text{ kJ/mol}; \quad S^\circ \text{CO}_2(\text{g}) = 213.6 \text{ J/K} \cdot \text{mol};$$

$$\Delta H_f^\circ \text{H}_2\text{O}(\text{l}) = -285.8 \text{ kJ/mol}; \quad S^\circ \text{H}_2\text{O}(\text{l}) = 69.9 \text{ J/K} \cdot \text{mol};$$

$$S^\circ \text{O}_2(\text{g}) = 205.0 \text{ J/K} \cdot \text{mol}$$