

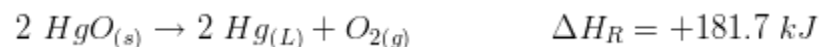
Enthalpy, Entropy, and Free Energy Worksheet

CK-12 Foundation Chemistry

Name _____ Date _____

- As the amount of energy required to decompose a compound increases, the thermodynamic stability of the compound _____.
 - increases
 - decreases
 - remains constant
 - varies randomly
- The enthalpy of formation for a free element is
 - 0 *kJ/mol*.
 - 1 *kJ/mol*.
 - 10 *kJ/mol*.
 - 100 *kJ/mol*.
 - variable.

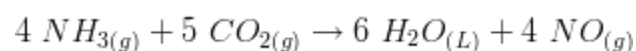
Questions 3 and 4 relate to the following equation and ΔH_R value.



- Which of the following can definitely be concluded from the equation and heat of reaction above?
 - The reaction is spontaneous.
 - The reaction is non-spontaneous.
 - The reaction is endothermic.
 - The reaction is exothermic.
 - None of these.
- From the equation and heat of reaction above, what is the ΔH_f of *HgO*?
 - 181.7 *kJ/mol*
 - 181.7 *kJ/mol*
 - 0 *kJ/mol*
 - 90.9 *kJ/mol*
 - 90.9 *kJ/mol*
- Which of the following four substances is the most thermodynamically stable? Use the data in the Thermodynamic Data Table at the bottom of the worksheet.
 - NH_{3(g)}*
 - CO_{2(g)}*
 - H_{2O(l)}*
 - NO(g)*
- The free energy of a reaction is the combination of _____ and _____.
 - heat and work

- B. pressure and volume
 - C. enthalpy and entropy
 - D. internal energy and PV
 - E. None of these.
7. All reactions that occur spontaneously must have a negative _____.
- A. $T\Delta S$
 - B. ΔG
 - C. ΔH
 - D. ΔS
 - E. All of these.

Questions 8, 9, 10, and 11, relate to the equation shown below.



8. Use the data in the Thermodynamic Data Table at the bottom of this worksheet to find the ΔH_R for the reaction above?
- A. $+92.8 \text{ kJ}$
 - B. -92.8 kJ
 - C. -806.3 kJ
 - D. $+806.3 \text{ kJ}$
 - E. None of these.
9. Use the data in the Thermodynamic Data Table at the bottom of this worksheet to find the ΔG_R for the reaction above?
- A. -981.6 kJ
 - B. $+981.6 \text{ kJ}$
 - C. -269.0 kJ
 - D. $+269.0 \text{ kJ}$
 - E. None of these.
10. Use the data in the Thermodynamic Data Table at the bottom of this worksheet to find the ΔS_R for the reaction above?
- A. -575.9 J/°
 - B. $+575.9 \text{ J/}^\circ$
 - C. -1419.1 J/°
 - D. $+1419.1 \text{ J/}^\circ$
 - E. None of these.
11. Use the ΔH_R you found in question 6 and the ΔS_R you found in question 8 to calculate ΔG_R for this reaction.
- A. 634.7 kJ
 - B. -634.7 kJ
 - C. 977.9 kJ
 - D. -977.9 kJ
 - E. None of these.

12. Find ΔS for the reaction, $2 \text{NO}_{(g)} + \text{O}_{2(g)} \rightarrow 2 \text{NO}_{2(g)}$.

- A. -146.5 J/K
- B. $+146.5 \text{ J/K}$
- C. -16.5 J/K
- D. $+16.5 \text{ J/K}$
- E. None of these.

12. Find ΔG_R for the reaction, $2 \text{H}_2\text{O}_{(g)} + 2 \text{F}_{2(g)} \rightarrow \text{O}_{2(g)} + 4 \text{HF}_{(g)}$.

- A. -1550.0 kJ
- B. $+1550.0 \text{ kJ}$
- C. -635.6 kJ
- D. $+635.6 \text{ kJ}$
- E. None of these.

13. What is the change in enthalpy for $4 \text{Al}_{(s)} + 3 \text{O}_{2(g)} \rightarrow 2 \text{Al}_2\text{O}_{3(s)}$?

- A. 0 kJ
- B. -1657.7 kJ
- C. $+1657.7 \text{ kJ}$
- D. $+3351.4 \text{ kJ}$
- E. -3351.4 kJ

14. What is the change in entropy for $4 \text{Al}_{(s)} + 3 \text{O}_{2(g)} \rightarrow 2 \text{Al}_2\text{O}_{3(s)}$?

- A. 0 J/K
- B. -626.7 J/K
- C. $+626.7 \text{ J/K}$
- D. -500.0 J/K
- E. $+500.0 \text{ J/K}$

15. Use the results from questions 14 and 15 to determine under what conditions this reaction will be spontaneous.

- A. This reaction will be spontaneous at all temperatures.
- B. This reaction will never be spontaneous at any temperature.
- C. This reaction will be spontaneous at high temperatures.
- D. This reaction will be spontaneous at low temperatures.

Thermodynamic Properties of Some Substances (at

Substance	ΔH_f° (kJ/mol)	ΔG_f° (kJ/mol)	S° (J/mol · K)
$Al_{(s)}$	0	0	+28.3
$Al_2O_{3(s)}$	-1675.7	-1582.3	+50.9
$CO_{(g)}$	-110.5	-137.2	+197.7
$CO_{2(g)}$	-393.5	-394.4	+213.7
$F_{2(g)}$	0	0	+202.8
$HF_{(g)}$	-271.1	-273.2	+173.8
$H_2O_{(L)}$	-285.8	-237.1	+69.9
$H_2O_{(g)}$	-241.8	-228.6	+188.8
$NH_{3(g)}$	-46.1	-16.5	+192.5
$NO_{(g)}$	+90.3	+86.6	+210.8
$NO_{2(g)}$	+33.2	+51.3	+240.1
$O_{2(g)}$	0	0	+205.1