

Entropy and Gibbs Free Energy

1. Consider the following energy levels, each capable of holding two objects:

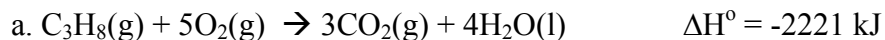
$$E = 2\text{kJ} \text{ ___}$$

$$E = 1\text{kJ} \text{ ___}$$

$$E = 0 \text{ \underline{XX}}$$

Draw all the possible arrangements of the two identical particles (represented by X) in the three energy levels. What total energy is most likely, that is, occurs the greatest number of times? Assume that the particles are indistinguishable from each other.

2. Calculate ΔS_{sur} for the following reactions at 25°C and 1 atm.



3. At what temperatures will the following processes be spontaneous?

a. $\Delta H = -18\text{kJ}$ and $\Delta S = -60\text{J/K}$

b. $\Delta H = +18\text{kJ}$ and $\Delta S = +60\text{J/K}$

c. $\Delta H = +18\text{kJ}$ and $\Delta S = -60\text{J/K}$

d. $\Delta H = -18\text{kJ}$ and $\Delta S = +60\text{J/K}$

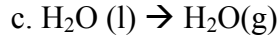
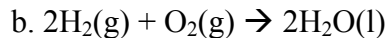
4. For ammonia (NH_3), the enthalpy of fusion is 5.65 kJ/mol and the entropy of fusion is $28.9 \text{ J/K} \cdot \text{mol}$.

a. Will $\text{NH}_3(\text{s})$ spontaneously melt at 200K ?

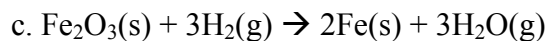
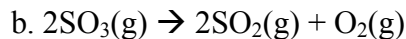
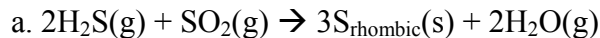
b. What is the approximate melting point of ammonia?

5. Predict the sign of ΔS° for each of the following changes.

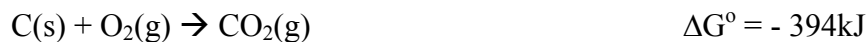
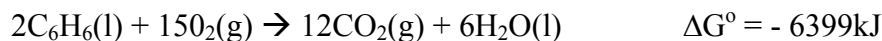




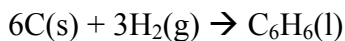
6. Predict the sign of ΔS° and then calculate ΔS° for each of the following reactions.



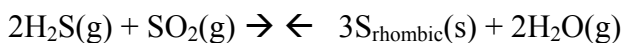
7. Given the following data:



Calculate ΔG° for the reaction



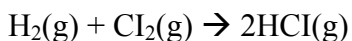
8. Using data from Appendix 4, Calculate ΔG for the reaction



For the following conditions at 25°C :

$$P_{\text{H}_2\text{S}} = 1.0 \times 10^{-4} \text{ atm}, \quad P_{\text{SO}_2} = 1.0 \times 10^{-2} \text{ atm}, \quad \text{and} \quad P_{\text{H}_2\text{O}} = 3.0 \times 10^{-2} \text{ atm}$$

9. Consider the reaction



- Calculate ΔH° , ΔS° , ΔG° , and K (at 298 K).
- If $\text{H}_2(\text{g})$, $\text{Cl}_2(\text{g})$, and $\text{HCl}(\text{g})$ are placed in a flask such that the pressure of each gas is 1 atm, in which direction will the system shift to reach equilibrium at 25°C ?