

Spontaneity and Free Energy

Assignment

1. For each of the following pairs, circle the situation which favors a spontaneous reaction:

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|----|------------------------------------|----|------------------------------------|
| a) | endothermic reaction | or | exothermic reaction |
| b) | negative value of ΔH° | or | positive value of ΔH° |
| c) | negative value of ΔS° | or | positive value of ΔS° |
| d) | increasing entropy | or | decreasing entropy |
| e) | positive value of ΔG° | or | negative value of ΔG° |

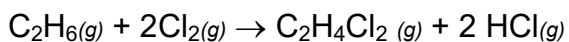
2. Describe the circumstances where:

- a) $\Delta H_f^\circ = 0$ _____
- b) $S = 0$ _____
- c) $\Delta G_f^\circ = 0$ _____
- d) $\Delta G = 0$ _____

3. Which one of the following shows an increase in entropy:

- a) dissolving sugar in a cup of hot tea.
 - b) arranging a pack of playing cards into suits.
 - c) building a sand castle on the beach.
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4. Using values of ΔG_f° from the table calculate ΔG° for the following reaction **and** tell whether or not the reaction will occur spontaneously. Show your work clearly. Use the formula $\Delta G = \Sigma \Delta G_{\text{products}} - \Sigma \Delta G_{\text{reactants}}$



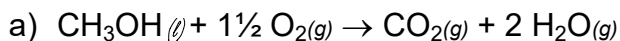
Substance	ΔG_f° (kJ/mol)
$\text{C}_2\text{H}_6(g)$	-32.9
$\text{Cl}_2(g)$	0.0
$\text{C}_2\text{H}_4\text{Cl}_2(g)$	-80.3
$\text{HCl}(g)$	-95.2

Is the reaction spontaneous?

5. Calculate ΔG° using the formula $\Delta G = \Delta H - T\Delta S$

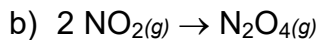
Also, for each question, tell whether or not the reaction will be spontaneous.

Values for ΔH and ΔS are given. All reactions take place at 25°C (298 K). Remember to convert ΔS values to kJ.



$$\Delta H = -638.4 \text{ kJ}$$

$$\Delta S = 156.9 \text{ J / K}$$



$$\Delta H = -57.2 \text{ kJ}$$

$$\Delta S = -175.9 \text{ J / K}$$

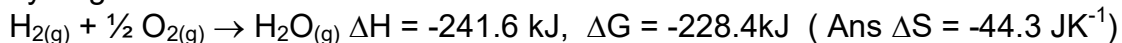
6. Calculate ΔG° for the following reaction using values of ΔG_f° obtained from the Table of Thermochemical Data. Will the reaction be spontaneous?

Use the formula $\Delta G = \Sigma \Delta G_{\text{products}} - \Sigma \Delta G_{\text{reactants}}$

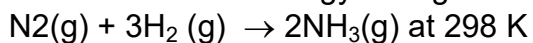


7. For a certain spontaneous reaction, the change in enthalpy (ΔH°) is -92.0 kJ and $\Delta G^\circ = -50.2$ kJ at 25°C. Calculate ΔS .
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8. Calculate the entropy change ΔS per mole for the following reaction: Combustion of hydrogen in a fuel cell at 298 K



9. Calculate the free energy change for the reaction:



$$\Delta H = -92.4 \text{ kJ}, \quad \Delta S = -197.6 \text{ JK}^{-1} \quad (\text{Ans } \Delta G = -33.5 \text{ kJ})$$

10. For the reaction $\text{Ag}_2\text{O}(s) \rightarrow 2\text{Ag}(s) + \frac{1}{2} \text{O}_2(g)$ $\Delta H = 30.56 \text{ kJ}$, $\Delta S = +66 \text{ JK}^{-1}$ at 1 atm pressure. Calculate the temperature at which the free energy change is equal to zero. Predict the nature of the reaction at this temperature and below this temperature.

$$(\text{Ans: } 463 \text{ K})$$
