Gibbs Free Energy - Reading Guide

*section 16.4 in OpenStax*

The change in **Gibbs Free Energy** can be used to predict whether a reaction is spontaneous. Based on the following equation, we can determine the effect of ∆H, ∆S and T on spontaneity:

∆G° =

A decrease in Gibbs free energy (∆G < 0) indicates a process is \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.

Work through Example 16.7. Then use the following data to calculate ∆Gorxn for the equation below using **enthalpy and entropy of formation** values. Assume 25°C.

NO(g) + ½ O2(g) → NO2(g)

|  |  |  |
| --- | --- | --- |
| Compound | ∆H(kJ/mol) | So (J/mol.K) |
| NO(g) | 91.3 | 210.8 |
| O2(g) | 0 | 205.2 |
| NO2(g) | 33.2 | 240.1 |

*(ans. ΔH°rxn =* –*58.1 kJ, ΔS°rxn =* –*73.3 J/K, ΔG°rxn =* –*36.3 kJ)*

∆Gorxn can also be calculated from tabulated values of ∆Gof.

Work through Example 16.8a. Then use the data below to calculate ∆Gorxn using **free energies of formation**.

NO(g) + ½ O2(g) → NO2(g)

|  |  |
| --- | --- |
| Compound | ∆G(kJ/mol) |
| NO(g) | 87.6 |
| O2(g) | 0 |
| NO2(g) | 51.3 |

*(ans. ΔG°rxn =* –*36.3 kJ)*

A third method to calculate ∆Gorxn is using Hess’s Law. Determine the value of ∆Gorxn for the target equation by using the three reactions provided. (*For a review of Hess’s Law, refer to chapter 5.3*).

Target equation: N2O (g) + NO2 (g) → 3 NO (g)

2 NO (g) + O2 (g) → 2 NO2 (g) Gorxn = –71.2 kJ

N2 (g) + O2 (g) → 2 NO (g) Gorxn = +175.2 kJ

2 N2O (g) → 2 N2 (g) + O2 (g) Gorxn = –207.4 kJ

*(ans. ΔG°rxn = 107.1 kJ)*

The ΔH, ΔS and Temperature (T) all have an effect on spontaneity. Complete the following table by specifying the sign (+/–) at low and high temperatures.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **ΔH** | **ΔS** | **ΔG** | |
|  | Sign | | **Low T** | **High T** |
| a) | – | + |  |  |
| b) | + | – |  |  |
| c) | – | – |  |  |
| d) | + | + |  |  |

Work through Example 16.9. Then, for the following reactions, describe the changes in entropy and specify the temperature conditions required for spontaneity. *No calculation is required.*

|  |  |  |  |
| --- | --- | --- | --- |
|  | **∆H** | **∆S sign** | **Temperature Condition for Spontaneity** |
| A (g) → A(s) | –120 kJ |  |  |
| B (g) → 2C (g) | –25 kJ |  |  |
| 2X (g) → 3Z (g) | –65 kJ |  |  |

**End of Chapter 16 Practice Problems**

#31, 33a–c, 35,

For detailed solutions to these problems, go to the [OpenStax website](https://openstaxcollege.org/textbooks/chemistry/resources) and download the “Student Answer and Solution Guide.”