Answer on Question #46320, Chemistry, Other

Question

When is a reaction is called spontaneous ?

Answer

A spontaneous process is the time-evolution of a system in which it releases free energy (usually as heat) and moves to a lower, more thermodynamically stable energy state. The sign convention of changes in free energy follows the general convention for thermodynamic measurements, in which a release of free energy from the system corresponds to a negative change in free energy, but a positive change for the surroundings.

For a reaction at constant temperature and pressure, ΔG in the Gibbs free energy is:

$$\Delta G = \Delta H - T\,\Delta S,$$

The sign of ΔG depends on the signs of the changes in enthalpy (ΔH) and entropy (ΔS), as well as on the absolute temperature (T, in kelvin). ΔG changes from positive to negative (or vice versa) where

$$T = \Delta H/\Delta S.$$

For heterogeneous systems where all of the species of the reaction are in different phases and can be mechanically separated, the following is true.

- When ΔG is negative, a chemical reaction proceeds spontaneously in the forward direction.
- When ΔG is positive, the chemical reaction proceeds spontaneously in reverse.
- When ΔG is zero, the reaction is in equilibrium, with no net change taking place over time.

We can further distinguish four cases within the above rule just by examining the signs of the two terms on the right side of the equation.

- When ΔS is positive and ΔH is negative, a reaction is always spontaneous
- When ΔS is positive and ΔH is positive, a reaction is spontaneous at high temperatures, where exothermicity plays a small role in the balance.
- When ΔS is negative and ΔH is negative, a reaction is spontaneous at low temperatures, where exothermicity is important.
- When ΔS is negative and ΔH is positive, a process is not spontaneous at any temperature, but the reverse process is spontaneous.

For Homogeneous systems where all of the species of the reaction are in the same phase, ΔG cannot accurately predict reaction spontaneity.