

4.1: Introduction

Three ***Laws of Thermodynamics*** describe the flow and transfer of energy in the universe.

1. **Energy can neither be created nor destroyed.**

2. ***Universal entropy (disorder) is always increasing****.*

3. ***Entropy declines with temperature*** -as temperatures approach absolute zero, so goes entropy

In living systems, we do not have to worry about the third law because equations for energy exchange in living systems already reflect the temperature dependence of entropy changes during reactions. Here we look at how we came to understand basic thermodynamic principles and how they apply to living systems. First, we will look at different kinds of energy and at how redox reactions govern the flow of energy through living things. Next, we will try to understand some simple arithmetic statements of the *Laws of Thermodynamics* for *closed systems* and then at how they apply to chemical reactions conducted under ***standard conditions***. Finally, since there really is no such thing as a ***closed system***, we look at the energetics of reactions occurring in open systems. For an excellent discussion of how basic thermodynamic principles apply to living things, see Lehninger A. (1971) *Bioenergetics: The Molecular Basis of Biological Energy Transformation.* Benjamin Cummings, San Francisco.

Learning Objectives

When you have mastered the information in this chapter, you should be able to:

1. explain the difference between *energy transfer* and *energy transduction.*

2. compare and contrast *potential* vs. *kinetic* as well as other categories of energy (e.g.,

mass, heat, light…, etc*.).*

3. explain the reciprocal changes in universal free energy and entropy.

4. derive the algebraic relationship between *free energy*, *enthalpy* and *entropy.*

5. state the difference between *exothermic*, *endothermic*, *exergonic*, and *endergonic*

reactions

6. predict changes in free energy based on changes in the concentrations of reactants and products in closed systems and open systems.

7. explain how the same reaction can be endergonic but will (under appropriate conditions) release free energy.

8. predict whether a biochemical reaction will release free energy if it is exothermic, and if so, under what conditions (you should be able to do this after working some sample problems of closed system energetics).

9. distinguish between the equilibrium and steady-state of reactions and explain how an endergonic reaction could also be spontaneous (i.e., could release free energy).