## SOLUTIONS TO PROBLEMS

#### Chapter 1

- L. An amino or imino group gives a molecule a positive charge; a carbenylate or phosphoryl group gives a molecule a negative charge.
- A. Thiol isulthydrylls group.
  - B Carbonyl group
  - C. Armide linkage
  - D. Phosphounhydride (pyrophosphoryl) linkage
  - E. Phosphoryl group (P.):
  - F. Hlydroxyl group.
- 3. Hydrolysis reactions tend to occur with an increase in entropy, because the highly ordered polymer is broken down into separate units.
- Typical prokaryotic cells are 1–10 µm in diameter, so T. namibiousis is about 10-300 times larger (or has 1000 to 27 million times the volume). Typical eukaryotic cells are 10-100 µm in diameter, so-T. numblemais is about the same size or up to 30 times larger (or has the same to 27,000 times the volume).
- 5. The data indicate that eukaryotes are more similar to the archaea thus to the eubacteria.
- 6: (a) Liquid water, (b) ice has less entropy at the lower temperature.
- 7. (a) Decreases, (b) increases, (c) increases, (d) no change.
- 8. No. When the change in enthalpy is positive and the change in entropy is negative, the free energy change for the process is greater than zero, which makes the process unfavorable.
- 9. (a) False. A spontaneous reaction occurs in only one direction.
  - (b) False. Thermodynamics does not specify the rate of a reaction.
  - (c) True. (d) True. A reaction is spontaneous as long as ΔS > ΔWT.
- 10. Gas T = 273 + 10 = 283 K.
  - $\Delta G = \Delta H T\Delta S$  $\Delta G = 15 \text{ kJ} + (283 \text{ K})(0.05 \text{ kJ} \cdot \text{K}^{-1})$
  - $-15 14.15 \, kJ 0.85 \, kJ$

 $\Delta G$  is greater than zero, so the reaction is not spontaneous.

- (b) T 273 + 80 353 K
- $\Delta G = \Delta M T\Delta S$
- $\Delta G = 15 \text{ kJ} (353 \text{ K}) \cdot 00.05 \text{ kJ} \cdot \text{K}^{-1}$ 
  - -15 17.65 kJ -2.65 kJ

ΔεG is less than zero, so the reaction is spontaneous.

- II.  $\Delta G = \Delta H T\Delta S$ 
  - $\Delta G = -7000 \text{ J} \cdot \text{mol}^{-1} (298 \text{ K})(-25 \text{ J} \cdot \text{K}^{-1} \cdot \text{mol}^{-1})$
  - $\Delta G = -7000 + 7450 J \cdot mol^{-1} = 450 J \cdot mol^{-1}$

The reaction is not spontaneous because  $\Delta G > 0$ . The temperature must be decreased in order to decrease the value of the  $T\Delta S$  term.

12. 
$$\Delta G^{**} = -RT \ln \frac{\{C\}}{1\Delta L(B)}$$

- $= -18,000 \text{ J} \cdot \text{mol}^{-1} = -18 \text{ kJ} \cdot \text{mol}^{-1}$
- 13.  $\Delta G^{in} = -RT \ln K_{in} = -RT \ln(|C||D|/|A||B|)$ 
  - -(8.314.3 · K <sup>-1</sup> · mol <sup>-1</sup>) (298 K) ln((3 × 10 <sup>-1</sup>) (5 × 10 <sup>-1</sup>) (10 × 10 °) (15 × 10 °)
    - 5700 J mol \* 5.7 kJ mol \*

Since  $\Delta G^{**}$  is positive, the reaction is endergonic under standard conditions.

- 14.  $K_{\infty} = e^{-2dT/RT} = e^{-(-200000 + ood^2)(0.7044 + K^2 + ood^2)(200 K)}$
- $-4.6 \times 10^{5}$
- From Eq. 1-17, K<sub>eq</sub> = [G6P]/[G1P] = e<sup>-367-167</sup>

[G6P]/[G1P] = e^-c-Trible and "planters - K" - mel" scores KG6PMDGHP1 - 17.6

 $1GIPPDG6P1 \rightarrow 0.057$ 

- 16. The cell membrane must be semipermeable so that the cell can retain executal compounds while allowing nutrients to enter and
- 17. Membrane-enclosed cellular compartments are typical of enkaryotic but not prokaryotic cells.
- Concentration (number of moles)/(volume)

Volume =  $(4/3) \propto r^3 = (4/3) \times (5 \times 10^{-7} \text{ m})^3$  $-5.24 \times 10^{-10} \,\text{m}^3 - 5.24 \times 10^{-10} \,\text{L}$ 

Moles of protein = (2 molecules)/(6.022 × 10<sup>23</sup> molecules · mol<sup>-1</sup>) - 3.32 × 10<sup>-24</sup> mod

Concentration =  $(3.32 \times 10^{-14} \text{ moly}(5.24 \times 10^{-16} \text{ L})$  $-6.3 \times 10^{-9} M - 6.3 \text{ eM}$ 

 Number of molecules = (molar conc.)(volume) (6.022 × 10<sup>23</sup> molecules \* mol<sup>-1</sup>3

> $= (1.0 \times 10^{-3} \text{ mod} \cdot \text{L}^{-1})(5.24 \times 10^{-16} \text{L})$ (6.022 × 10<sup>13</sup> molecules - mol<sup>-1</sup>)

 $-3.2 \times 10^6$  molecules

 In order for \(\Delta G\) to have a negative value (a spontaneous reaction).  $T\Delta S$  must be greater than  $\Delta H$ .

 $T\Delta S \ge \Delta M$ 

 $T \gg \Delta M \Delta S$ 

 $T > 7000 \text{ J} \cdot \text{mol}^{-1}/20 \text{ J} \cdot \text{K}^{-1} \cdot \text{mol}^{-1}$ 

F 15 350 K or 7770

21. (a) Because  $K_{eq} = \frac{|\mathbb{R}|}{|\Omega|} = 25$ , at equilibrium, the concentration of

R is 25 times greater than the concentration of Q. When equal concentrations of O and R are mixed, molecules of O will be converted to molecules of R.

(b) Let x = amount of Q converted to R, so that [R] will be 50 μM +

x and [Q] will be  $50 \mu M - x$ . Since  $K_{eq} = \frac{\{R\}}{\{O\}^2} = 25$ .

$$50 + x = 25(50 - x)$$
  
 $50 + x = 1250 - 25x$ 

 $26\pi - 1200$ 

x = 46.15 $[R] = 50\mu M + 46.15\mu M = 96.15\mu M$ 

 $||Q|| = 50 \mu M - 46.15 \mu M = 3.85 \mu M$ 

22. At 10°C = 283 K (1/T = 0.00353), K<sub>eq</sub> = 100 and ln K = 4.61. At 30°C = 303 K (1/T = 0.00330),  $K_{eq} = 10$  and In K = 2.30.

These two points generate a line on a van't Hoff plot (In K., versus L/T) with a positive slope that is equal to  $(-\Delta M'/00)$ .  $\Delta M$  must therefore be negative, indicating that enthalpy decreases during the reaction (heat is given off).

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