CONCEPT: GIBBS FREE ENERGY

- Recall the Gibbs free energy equation: $\Delta G = \Delta H - T\Delta S$
- Gibbs free energy: energy available to do _______.
  - □ *Work* is done when concentrations in a system __________ (no work is done at *equilibrium*, $\Delta G = 0$).
  - □ Concentrations within a system influence the *direction* of a reaction.

Reaction Direction

- Cellular reactions are almost *never at* _______________ due to several factors.
- When a reaction is *not* at equilibrium, the *reaction quotient* (**Q**) replaces the equilibrium constant: $Q = \frac{[\text{Products}]}{[\text{Reactants}]}$
  - □ ____ __________ Principle: when equilibrium is disturbed, the reaction direction proceeds to *restore* equilibrium.

EXAMPLE: Consider the reaction below & complete the chart:

$$CO_{(g)} + 2H_{2(g)} \longleftrightarrow CH_3OH_{(g)}$$

$$Q = \frac{[\quad\quad]}{[\quad][\quad]} \qquad K_{eq} = \frac{[CH_3OH]_{eq}}{[CO]_{eq}[H_2]^2_{eq}}$$

Comparing Q & K_{eq}	Reaction Direction
$Q < K_{eq}$	
$Q > K_{eq}$	
$Q = K_{eq}$	

Reaction Under Standard Conditions˚

- Standard conditions allow scientists to compare different reactions under the same conditions.
- Equilibrium constant can be used to calculate the change in free energy under ________ ___________ (ΔG°).
  - □ ΔG is the *actual* change in free energy of a system under any condition.

EXAMPLE:

Gibbs Free Energy Under Standard Conditions°

$$\Delta G^\circ = -RT\ \ln(K^\circ_{eq})$$

Standard Conditions°

- T → 25°C _____K
- R → 8.315 J/mol*K
- Pressure → 1 atm
- Concentration → 1M

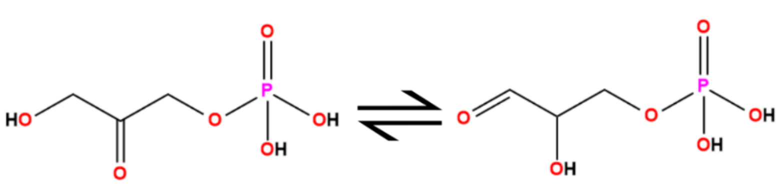
Reaction Under Physiological Conditions

- Standard conditions occur in a test tube in a lab, but *physiological* conditions _______ within biological systems.
  - □ ΔG° can be used to determine the *actual* change in free energy of a system under any condition (ΔG).

EXAMPLE: Calculate ΔG° & ΔG for the given reaction:

Gibbs Free Energy Under Any Conditions

$$\Delta G = \Delta G^\circ + RT\ \ln(Q)$$



Dihydroxyacetone-phosphate (DHAP) Glyceraldehyde-3-phosphate (G3P)

ΔG° =

$$K^\circ_{eq} = \frac{[\text{Products}]_{eq}}{[\text{Reactants}]_{eq}} = \frac{[\quad\quad]}{[\quad\quad]} = 0.0475$$

ΔG =

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PRACTICE: Consider a reaction where K_{eq}=1.6 but Q = 3.19. What direction will the reaction proceed?

a) Forward.
b) Reverse.
c) Forward & reverse reactions proceed equally.
d) Not enough information provided to make conclusions.

PRACTICE: At equilibrium, the reaction $A \rightleftharpoons B + C$ has the following component concentrations: [A] = 3 mM, [B] = 4 mM, and [C] = 10 mM. What is the standard free energy change for the reaction & is it endergonic or exergonic?

a) – 6418 J
b) 6418 J
c) 10,698 J
d) – 10,698 J

PRACTICE: ΔG°=141.7 kJ for the following reaction. Calculate ΔG: T=10˚C, [SO_3] = 25mM, [SO_2] = 50mM, & [O_2] = 75 mM.

$$2\ SO_3(g) \rightleftharpoons 2\ SO_2(g) + O_2(g)$$

a) – 6,437 J
b) 39,938 J
c) -155,127 J
d) 138,865 J