<u>Biological Systems in AP Chemistry</u>

In the 2013-14 revisions to the AP Chemistry curriculum, a significant amount of language has been placed in the curriculum document surrounding the importance of fundamental chemistry concepts in biological systems. These skills have been explicitly referenced in four out of six Big Ideas, one Science Practice, and two Learning Objectives.

Big Idea 2

Enduring understanding 2.B: Forces of attraction between particles (including the noble gases and also different parts of some large molecules) are important in determining many macroscopic properties of a substance, including how the observable physical state changes with temperature.
The properties of condensed phases and of many crucial <u>biological structures</u> are determined by the nature and strength of these interactions.

Essential knowledge 2.B.3: Intermolecular forces play a key role in determining the properties of substances, including <u>biological structures</u> and interactions.

e. The structure and function of many <u>biological systems</u> depend on the strength and nature of the various Coulombic forces.
   1. Substrate interactions with the active sites in <u>enzyme catalysis</u>
   2. Hydrophilic and hydrophobic regions in <u>proteins</u> that determine three- dimensional structure in water solutions

Big Idea 4

Enduring understanding 4.D: Reaction rates may be increased by the presence of a catalyst.
Catalysts, such as <u>enzymes in biological systems</u> and the surfaces in an automobile's catalytic converter, increase the rate of a chemical reaction.

Big Idea 5

Enduring understanding 5.D: Electrostatic forces exist between molecules as well as between atoms or ions, and breaking the resultant intermolecular interactions requires energy.
In many systems involving large molecules (both <u>biochemical systems</u> and synthetic polymer systems), the nonbonded interactions play important roles in the observed functions of the systems.

Essential knowledge 5.D.3: Noncovalent and intermolecular interactions play important roles in many <u>biological</u> and polymer systems.

Enduring Understanding 5.E: Chemical or physical processes are driven by a decrease in enthalpy or an increase in entropy, or both.
Importantly, in <u>biochemical systems</u>, some reactions that oppose the thermodynamically favored direction are driven by coupled reactions. Thus, a cell can use energy to create order (a direction that is not thermodynamically favored) via coupling with thermodynamically favored reactions. For example, many <u>biochemical syntheses</u> are coupled to the reaction in which ATP is converted to ADP + phosphate.

Essential knowledge 5.E.4: External sources of energy can be used to drive change in cases where the Gibbs free energy change is positive.

c. A thermodynamically unfavorable reaction may be made favorable by coupling it to a favorable reaction, such as the conversion of <u>ATP to ADP in biological systems</u>. In this context, coupling means the process involves a series of reactions with common intermediates, such that the reactions add up to produce an overall reaction with a negative ΔG.

Big Idea 6

Big Idea 6: Any bond or intermolecular attraction that can be formed can be broken. These two processes are in a dynamic competition, sensitive to initial conditions and external perturbations.
A wide range of equilibrium constants is possible; of particular significance are those that arise from acid-base chemistry, particularly as embodied in <u>*biochemical systems*</u> *where the value of K is such that significant amounts of both reactants and products are present.*

Essential knowledge 6.A.1: In many classes of reactions, it is important to consider both the forward and reverse reaction.

- **a.** Many readily observable processes are reversible. Examples include evaporating and condensing water, absorption of a gas, or dissolving and precipitating a salt. Relevant and interesting contexts include biological examples (<u>binding of oxygen to hemoglobin and the attachment of molecules to receptor sites in the nose</u>) and environmental examples (transfer of carbon between atmosphere and biosphere and transfer of dissolved substances between atmosphere and hydrosphere).

Essential knowledge 6.D.1: When the difference in Gibbs free energy between reactants and products (ΔG) is much larger than the thermal energy (RT), the equilibrium constant is either very small (for DG > 0) or very large (for $\Delta G < 0$). When DG is comparable to the thermal energy (RT), the equilibrium constant is near 1.

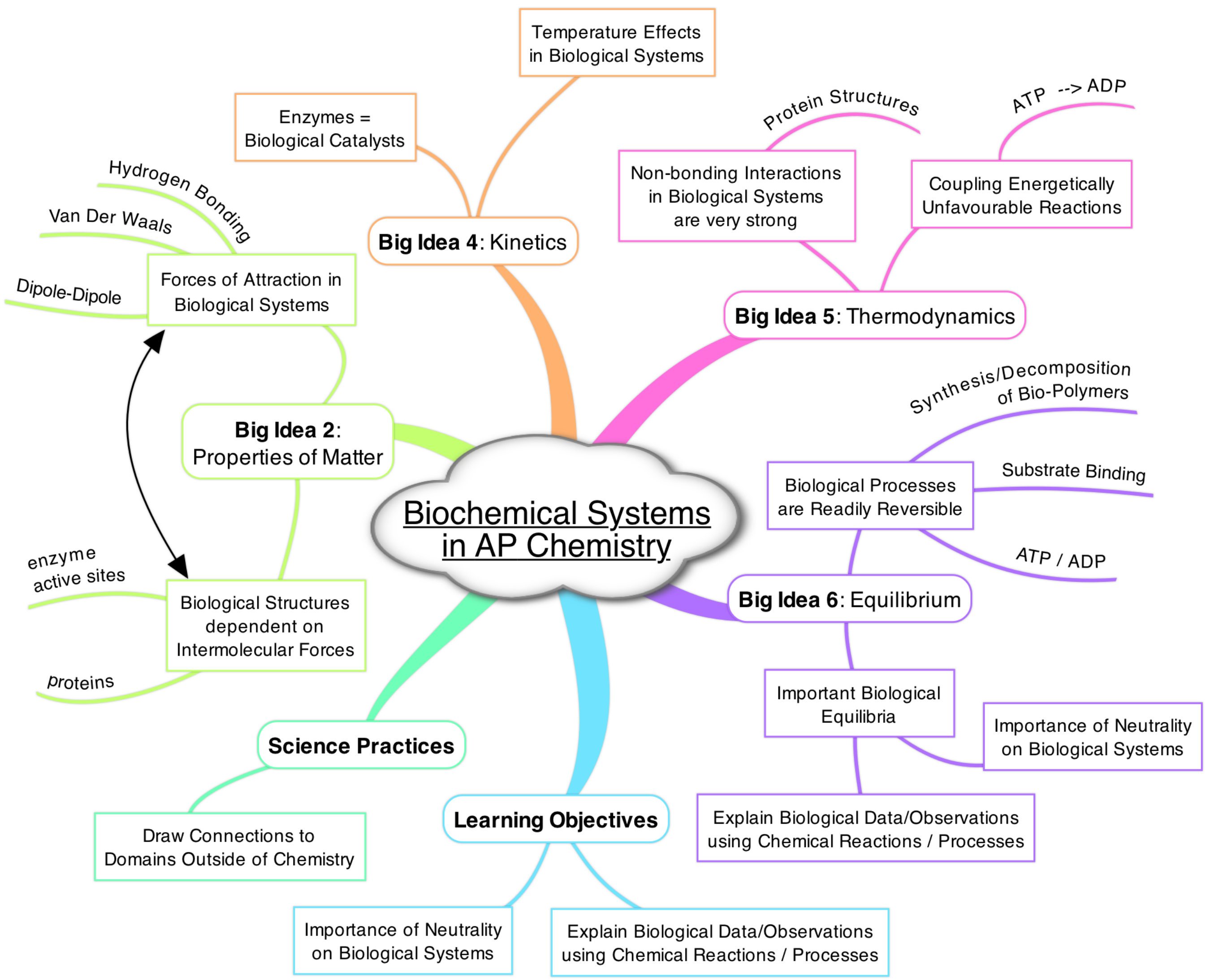
- **d.** Since K is directly related to free energy, when the magnitude of K is of primary interest, it is useful to consider whether a reaction is exergonic ($\Delta G < 0$) or endergonic ($\Delta G > 0$). (Exothermic versus endothermic is the useful distinction when the issue of interest is whether a reaction releases or consumes energy.) In many <u>biological applications</u>, the magnitude of K is of central importance, and so the exergonic/endergonic distinction is useful.

LO 6.1 The student is able to, given a set of experimental observations regarding physical, chemical, <u>biological</u>, or environmental processes that are reversible, construct an explanation that connects the observations to the reversibility of the underlying chemical reactions or processes.

LO 6.14 The student can, based on the dependence of Kw on temperature, reason that neutrality requires [H+] = [OH–] as opposed to requiring pH = 7, including especially the applications to <u>biological systems</u>.

Science Practices

Science Practice 7: The student is able to connect and relate knowledge across various scales, concepts, and representations in and across domains. *In addition to connecting concepts within chemistry, students should be able to draw connections to domains outside chemistry, such as the connection between* <u>*protein structure*</u> *(primary, secondary, and tertiary) in biology, and covalent versus non- covalent interactions in chemistry*



Sample Questions: AP Chemistry Practice Exam and Notes, Fall 2013 *NONE GIVEN*