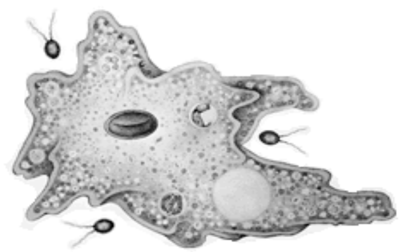
MCDB 1111 coreBIO: Midterm 2 - Fall 2017 NAME: ______________________________



Directions: There are 10 questions, each worth 10 points. Remember, you can check "no idea" and you will receive 1 point (no reasoning is required).

As before, in some cases you are asked to select the wrong answer, otherwise pick the correct answer. READ CAREFULLY to determine what the question wants you to do.

Q1: (4 points) A major factor that influences the rate of movement of a highly hydrophilic molecule out of the aqueous phase and across a cell's lipid bilayer membrane

☐ A. are the repulsive forces associated with its interactions with the hydrophobic region of the membrane

☐ ✓ B. its H-bonding interactions with water molecules

☐ C. the presence of London dispersion force-mediated van der Waals interactions ☐ no idea

Explain the logic of your response and why the incorrect answers are wrong or irrelevant.

(6 points) A- There is no repulsive force associated with hydrophobic molecules, only weak attractions

C - These stronger inter-molecular interactions act to hold hydrophilic molecules within the aqueous phase.

B- it is the H-bonding interactions between the hydrophilic molecula and water that are relevant here

Q2: (5 points) (WHICH IS **NOT** TRUE) **Compared to "H-bonding" interactions, London dispersion force-mediated van der Waals interactions:**

☐ A. are non-directional ☐ no idea

☐ B. occur between all molecules, regardless of their atomic composition

☐ C. ✓ occur <u>only</u> when molecules contain atoms with different electronegativities

Explain the logic of your response and why the incorrect answers are wrong or irrelevant.

(5 points) van der Waals interactions (based on London Dispersion Forces) are universal and non-directional (A and B). They are independent of atom electronegativities. If such electonegativities are present, they are referred to a polar interactions (which includes H-bonding). Such interactions are directional and not universal, since they depend upon a molecule's composition.

Q3: **(5 points)** **The unique properties of water (its high melting and boiling points, surface tension, etc.) are largely due to ….**

☐ ✓ A. its ability to take part in multiple H-bonds ☐ No idea.

☐ B. its ability to interact with other molecules through van der Waals interactions

☐ C. its small size

Explain the logic of your response and why the incorrect answers are wrong or irrelevant.

(5 points) It is these multiple H-bonds that drive the spacing of water molecules in ice (where thermal motion is lower) leading to lower density (which is why ice floats.

A. All molecules interact through vdW interactions, so there is nothing unique about that.

C. Other molecules that are small (example methane), have very different properties - very much unlike water.

Q4: **(5 points)** **A channel in a membrane is like a catalyst because it …**

☐ A. increases the speed at which molecules collide with the membrane

☐ B. changes the ΔG associated with the overall reaction

☐ ✓ C. decreases the energy needed to pass though the membrane ☐ no idea

Explain the logic of your response and why the incorrect answers are wrong or irrelevant.

(5 points) A catalyst does not directly influence the temperature of the system (which is what determines the speed of colliding molecules) - (option: although if a reaction occurs, the heat released can lead to an increase in system temperature). B. Again, catalysts have no effect on overall reaction ΔG, they do lead to changes the ΔGs of reaction intermediates.

Q5: A cell needs to import a water-soluble nutrient; this nutrient is present at a lower concentration outside the cell than within the cell. Make a model of a system that includes the components that would lead to the movement of the nutrient AGAINST its concentration gradient. START with a diagram of your model (→) and explain how it leads to a net flux of nutrient into the cell.

An ATP hydrolysis-driven pump to recreate gradient (in Na+ or H+ for example) and then an symporter that couples movement of gradient molecule (Na+ or H+) down its concentration gradient and the nutrient molecule up its concentration gradient (from a region of low concentration to high concentration). The energy held in first gradient needs to be sufficient to overcome the gradient in the nutrient.

Q6: **(5 points)** **Based on their structural components, you might argue that oxygenic photosynthesis and aerobic respiration are**

☐ A. analogous processes

☐ B. ✓ homologous processes

☐ C. have completely different and unrelated functions ☐ no idea

Explain the logic of your response and why the incorrect answers are wrong or irrelevant.

(5 points) Both systems use an electron transport chain (ETC) to generate a H+ gradient across the plasma membrane (or across the inner membranes of mitochondria and chloroplasts (optional: which are derived from aerobic and oxygenic photosynthetic proteobacterial and cyanobacteria) as well as membrane-bound (cytoplasmic facing) H+-driven ATP synthase. They differ in how high energy electrons are delivered to the ETC, but otherwise they are similar and presumably reflect the common ancestor from which they were derived.

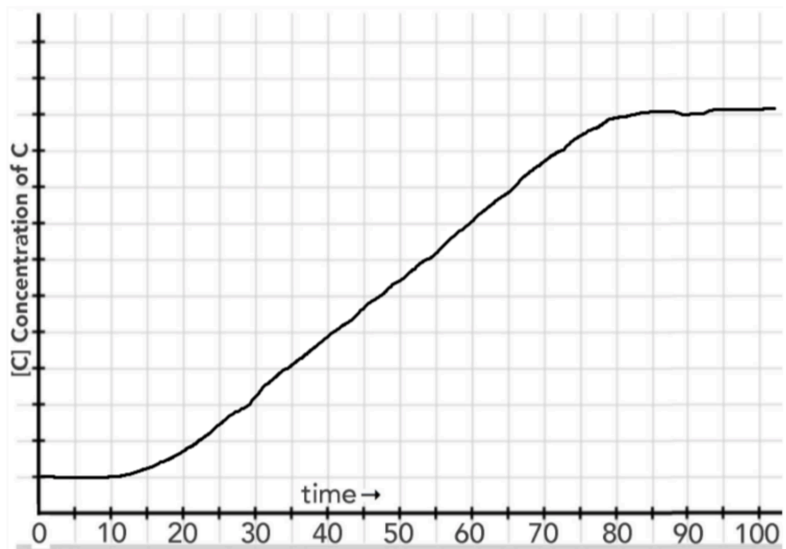
Q7: **(graph 3 points)** **There are two reactions occurring within a system:**

A + B ⇄ C + E + Q (unfavorable ΔG > 0)

and E + D ⇄ F (favorable, ΔG < 0)

By time = 0, the system has reached equilibrium. At time = 10 a large amount of D is added to the system, which again reaches equilibrium by t = 80. What happens to the concentration of C over time (draw and choose):

(3 points)



☐ ✓ A. it increases

☐ B. it is unchanged

☐ C. it decreases

☐ D. impossible to predict ☐ no idea

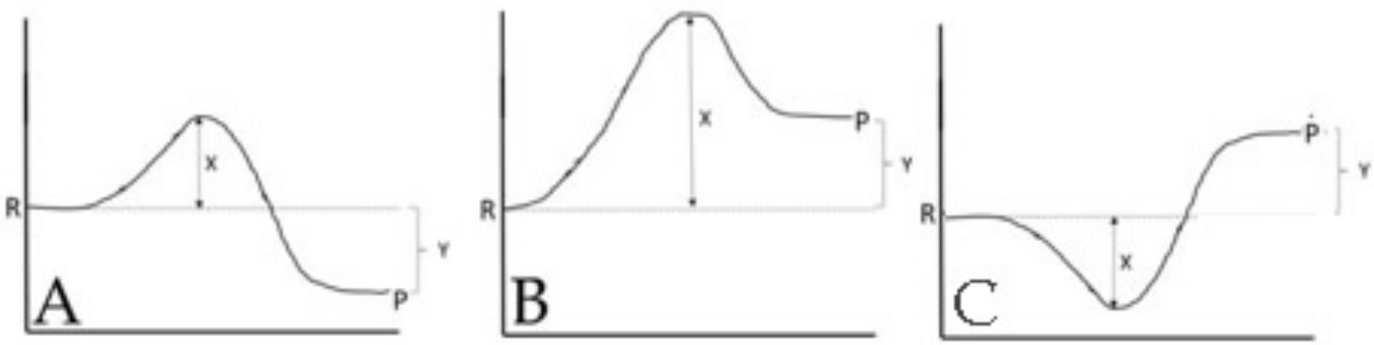
Explain (below) i) what is happening and ii) what, if anything, would change if Q were rapidly removed from the system.

(4 points) The two reactions are coupled (share E). At equilibrium concentrations do not change (0 to 10 and 80 to 100), but because of coupling, the first reaction will be driven when D is added and reacts with E. Removing Q would be expect to lead to a further increase in C.

Q8. **(10 points) Consider a bacterial cell carrying out aerobic (oxygen-requiring) respiration.** Using the cell diagram (→), indicate: 1) the location and direction of the H^+ gradient, 2) the electron transport chain, 3) the ATP synthase, and (with arrows) 4) the movements of H^+ and
5) where ATP is synthesized. ☐ NO IDEA

If the outer line is the plasma membrane of the bacterial cell, the H+ gradient is across this membrane (higher outside). The ETC is located within that membrane, as is the ATP synthase (although it is separate from the ETC). H+ move out of the cell through the ETC and into the cell through the ATP synthase. ATP is synthesized in the interior (the cytoplasm).

Q9 **(3 points) Part 1: Which of the three reaction diagrams reflects a thermodynamically favorable reaction?**



✓ ☐ ☐ ☐ no idea

Part 2: You now add a catalyst, and the reaction proceeds rapidly to equilibrium. Draw the effect of the added catalyst, using the reaction diagram you chose above.

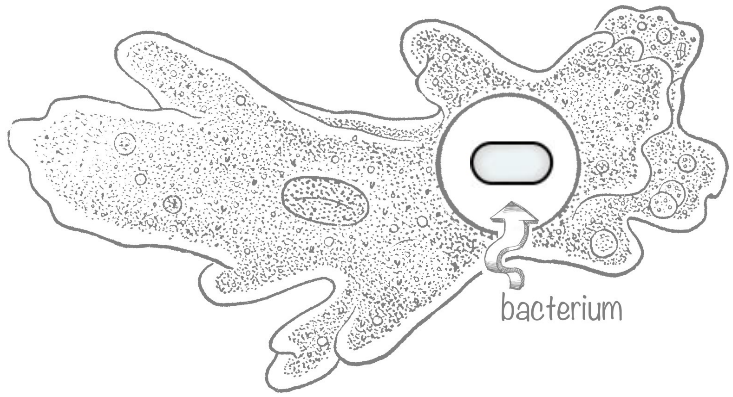
(3 points) The value of X will decrease, the activation energy will be reduced.

Part 3: Explain how a concentration gradient across a membrane is like a chemical reaction, and what types of catalysts may be involved.

(2 points) We can think of a water soluble solute $[S_o]$ outside the cell as a reactant, and the solute inside the cell as a product $[S_i]$. So the reaction is $[S_o] \leftrightarrows [S_i]$. The energy needed to leave the aqueous phase (and to pass through the membrane) corresponds to the activation energy of the reaction.

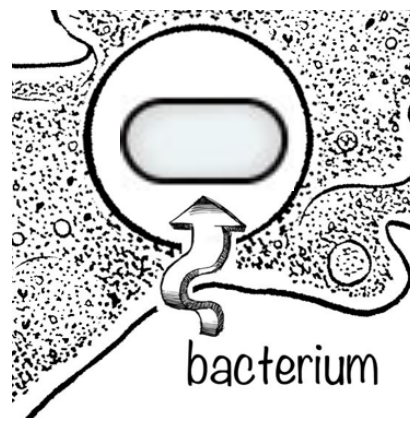
(2 points) Any channel or carrier for S will act as a catalyst for moving through the membrane. It does not change the overall thermodynamics of the initial reaction (although like all reactions, as the reaction comes to equilibrium, free energies of reactants = products.

Q10: (3 points) **Consider a predatory eukaryotic ancestor, which engulfs microbes, including aerobic bacteria, capturing them in intracellular, membrane-bound vesicles and then digesting them.** To digest the bacteria, the predatory cell must first make the interior of the vesicle acidic (increase $[H^+]$) leading to the activation of various digestive enzymes within the intracellular vesicle. **Draw (on the picture-above)** the molecular system(s) required to make the vesicle interior acidic, the direction of H^+ movement, and where ATP hydrolysis occurs in the eukaryotic predator.



(3 points) An ATPase that moves H^+ will be located in the vesicular membrane, with ATP hydrolysis occurring in cytoplasm (outside the vesicle. H^+ will move into the vesicle, increasing intravesicular $[H^+]$, making it acidic (pH = -log $[H^+]$.

Part 2: (3 points) **Now assume that the engulfed aerobic bacterium is not killed, but forms a stable endosymbiotic relationship with the engulfing cell. Such a relationship could be evolutionarily valuable (selected for) because ....**



- ❏ ✔ A. it is more efficient at extracting energy from food
- ❏ B. it does not need O_2 to generate ATP
- ❏ C. it is not possible, because not killing the bacteria will reduce the amount of food available to the host.
- ❏ no idea

Part 3: Justify your choice

(4 points) To be evolutionarily advantageous, the endosymbiotic system has to give the predator an advantage, provided that the improvement in energy capture is greater than the loss of energy to be gained by digesting the bacteria. The ability to move electrons to oxygen (generating water, rather than leaving lots of energy in molecules such as ethanol and lactic acid (from the book). Note that eating prey has a "one-off" advantage, establishing a mitochondria improves energy extraction from all future prey!

In an environment that contains molecular oxygen, organisms that can use O_2 as an electron acceptor have a distinct advantage; instead of secreting energy rich molecules, like ethanol, they release the energy poor (stable) molecules CO_2 and H_2O.