CSUSM
STEM Success Center

BIOL 210: Metabolism, Energy, and Thermodynamics

1. What is the formula for Cellular Respiration?

2. What is the formula for Photosynthesis?

3. What type of pathway is Cellular Respiration?

4. What type of pathway is Photosynthesis?

5. A dog is laying on it's bed and runs to the door when it hears someone knock. What kind of energy did the dog have when lying down? When running to the door?

6. Two vsco girls leave their hydroflasks on the counter while they record a TikTok. Vsco girl 1 leaves her cap on her hydroflask. Vsco girl 2 leaves her cap off her hydroflask. What type of systems are their hydroflasks and why?

7. Draw the metabolic pathway using the following information:

   D makes J using A

   J makes G with the help of B

   G makes V

   too much V stops the function of B

   a. What would be your major product if you remove all of B?

b. What is B?

c. What relationship does V have with B?

8. Define the first and second laws of thermodynamics.

9. Given the first law of thermodynamics, why can an organism not reuse and recycle the energy they have (why do organisms have to consume energy)? How does this explanation relate to the second law of thermodynamics?

10. What is the change in Gibbs free energy of the following:
    a. $A + B \rightarrow C$ given that the reaction happens at 11°C, the change in heat is 430 cal, and the change in entropy is 19 cal/K

b. $D \rightarrow E + F$ at 43^{o} C , the change in heat is 560 cal, and $\Delta S = 6.8$ cal/K

c. $G + H \rightarrow I + K$ at 86^{o} F, $\Delta H = 256$ cal, and the change in entropy is 117 cal/K

d. Which (if any) of these reactions is spontaneous?

e. How does the ΔG of each reaction change if the reactions occur at human body temperature?

f. At what exact temperatures are these reactions at equilibrium?

Solutions

1. **What is the formula for Cellular Respiration?**

   $C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$ + energy/ATP

2. **What is the formula for Photosynthesis?**

   Sun's Energy (Light)

   $6CO_2 + 6H_2O \quad \rightarrow\rightarrow\rightarrow\rightarrow\rightarrow \quad C_6H_{12}O_6 + 6O_2$

3. **What type of pathway is Cellular Respiration?**

   Catabolic, because we are taking large molecules ($C_6H_{12}O_6$) and breaking it down into smaller molecules

4. **What type of pathway is Photosynthesis?**

   Anabolic, because we are using small molecules to create/build a large molecule ($C_6H_{12}O_6$)

5. **A dog is laying on it's bed and runs to the door when it hears someone knock. What kind of energy did the dog have when lying down? When running to the door?**

   When lying down: Potential energy, because the dog is not using any energy or exerting energy through an activity

   When running to the door: Kinetic Energy, because the dog is exerting energy in the form of heat and CO_2 by running

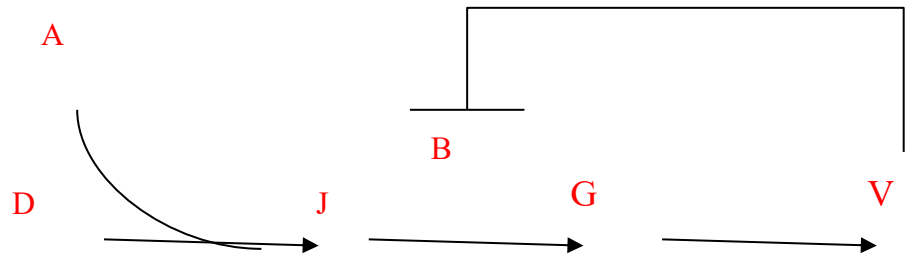
6. **Two vsco girls leave their hydroflasks on the counter while they record a TikTok. Vsco girl 1 leaves her cap on her hydroflask. Vsco girl 2 leaves her cap off her hydroflask. What type of systems are their hydroflasks and why?**

   Girl 1: a closed system because the is no mass transferred in the form of water vapor but there is still heat being transferred into and out of the hydroflask

   Girl 2: an open system, she has left the cap off allowing mass and heat to be transferred in and out of the hydroflask

   Note: while a hydroflask is highly insulated, it will still lose heat and any amount of heat transferred into and out of a system is still heat transference so we cannot say that Girl 2's hydroflask is an isolated system

7. **Draw the metabolic pathway using the following information:**



D makes J using A

J makes G with the help of B

G makes V

too much V stops the function of B

a. What would be your major product if you remove all of B?

J because there is no B to facilitate the change from J to G

b. What is B?

an enzyme, we know this because it is not consumed and helps to convert J to G, this is also shown because V is inhibiting B which only happens to enzymes

c. What relationship does V have with B?

feedback inhibition, because when there is too much of V the V bonds to B and stops it from converting J into G

8. **Define the first and second laws of thermodynamics.**

First Law: Energy conservation, energy cannot be created or destroyed only transformed

Second Law: When energy is transformed it increases the entropy of the universe

9. **Given the first law of thermodynamics, why can an organism not reuse and recycle the energy they have (why do organisms have to consume energy)? How does this explanation relate to the second law of thermodynamics?**

When an organism uses energy to do some action, some of that energy is lost as heat into the environment/universe. This is supported by the second law because the heat being released and the reduction of the energy within the system supports the idea that transformation of energy increases entropy of the universe.

10. **What is the change in Gibbs free energy of the following:**
    a. **A + B → C given that the reaction happens at 11°C, the change in heat is 430 cal, and the change in entropy is 19 cal/K**

$\Delta G = \Delta H - T\Delta S$

We need T in K: $11^{o}C + 273.15 = 284.15\ K$ $\Delta H = 430$ cal $\Delta S = 19$ cal/K

$\Delta G = 430\ cal - 284.15\ K\ (19\ cal/K) =$ -4968.85 cal

    b. **D → E + F at 43° C , the change in heat is 560 cal, and ΔS = 6.8 cal/K**

$43^{o}C + 273.15 = 316.15\ K$ $\Delta H = 560$ cal $\Delta S = 6.8$ cal/K

$\Delta G = 560\ cal - 316.15\ K\ (6.8\ cal/K) =$ -1589.83 cal

    c. **G + H → I + K at 20° F, ΔH = 675 cal, and the change in entropy is 5.5 cal/K**

We need T in K : $(20^{o}F + 459.67)(5/9) = 266.48\ K$ $\Delta H = 675$ cal $\Delta S = 5.5$ cal/K

$\Delta G = 675\ cal - 266.48\ K\ (5.5\ cal/K) =$ -790.66 cal

    d. **Which (if any) of these reactions is spontaneous?**

They are all spontaneous.

e. How does the ΔG of each reaction change if the reactions occur at human body temperature?

We know that body T is ~98.6° F. So we have to find T in K from this and use it for all the reactions. K = (98.6° F +459.67)(5/9) = 310.15 K

a.) ΔG = 430 cal - 310.15 K (19 cal/K) = -5462.85 cal

b.) ΔG = 560 cal - 310.15 K (6.8 cal/K) = -1549.02 cal

c.) ΔG = 675 cal - 310.15 K (5.5 cal/K) = -1030.83 cal

f. At what exact temperatures are these reactions at equilibrium?

We know that at equilibrium ΔG = 0 so we set all the reactions to 0 and solve for T.

a.) 0 = 430 cal - T(19 cal/K)

(-430 cal) / (-19 cal/K) = [- T(19 cal/K)] / (-19 cal/ K)

22.63 K = T

b.) 0 = 560 cal - T(6.8 cal/K)

(-560 cal) / (-6.8 cal/K) = [-T(6.8 cal/K)] / (6.8 cal/K)

82.35 K = T

c.) 0 = 675 cal - T(5.5 cal/K)

(-675 cal) / (-5.5 cal/K) = [-T(5.5 cal/K)] / (-5.5 cal/K)

122.72 K = T