Solutions to Practice Problems for Biochemistry, Session 5: Biochemical Reactions, Enzymes and ATP

Question 1

You are looking at the following biological reactions that are catalyzed by specific enzymes as shown below.

Compound A ⟷ (E1) Compound B

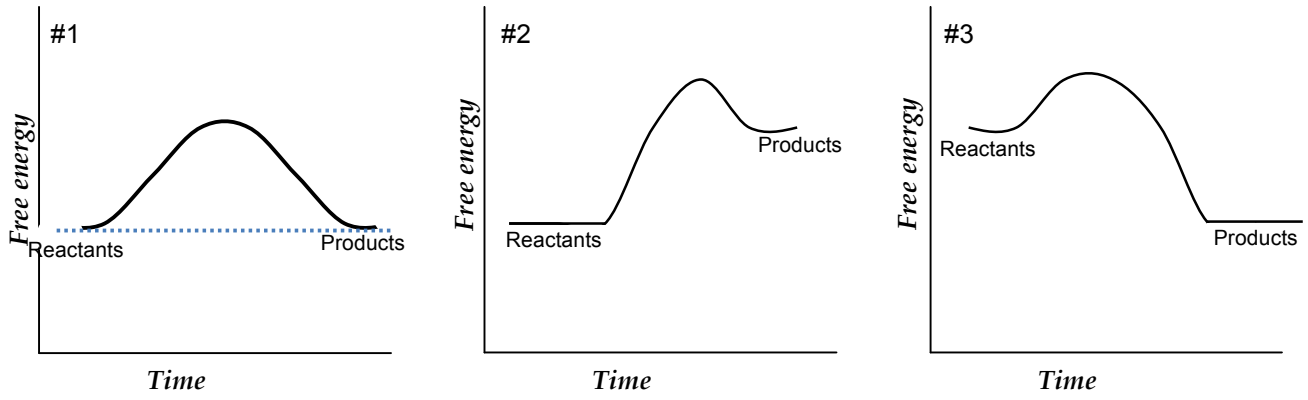
Compounds C + D ⟷ (E2) Compound E

Compound F ⟷ (E3) Compound G

Note:

- ***In Reaction #1,*** *Enzyme* ***E1*** *catalyzes the conversion of Compound A to Compound B. This reaction is* ***truly reversible*** *and the reverse reaction is as likely as the forward reaction.*
- ***In Reaction #2****, Enzyme* ***E2*** *catalyzes an* ***energy requiring reaction*** *that uses Compounds C and D as substrates to produce Compound E.*
- ***In Reaction #3****, Enzyme* ***E3*** *catalyzes an* ***energy producing reaction*** *that converts Compound F to Compound G.*

a) Draw the energy profiles of reactions #1, #2 and #3 on the axes given below. On the diagram, please label the reactants and the products.



b) You decide to reproduce Reaction #2 in three test tubes. You may assume that this biological reaction occurs at a **37°C** and a **pH of 7.4** under **normal conditions**.

- ***Test tube #1:*** *You perform the reaction at* ***70°C*** *and a* ***pH of 7.4*** *and observe that no Compound E is produced. When the temperature is brought to* ***37°C,*** *Compound E is produced at a rate similar to normal condition.*
- ***Test tube #2:*** *You perform the reaction at* ***37°C*** *and a* ***pH of 10.4*** *and observe that no Compound E is produced. When the pH is brought to* ***7.4****, Compound E is produced at a rate similar to normal condition.*
- ***Test tube #3:*** *You perform the reaction at* ***37°C*** *and a* ***pH of 7.4*** *in the* ***presence of proteases*** *and observe that no Compound E is produced. The effect of protease treatment persists even after its removal from reaction mixture.*

Explain the effect of the changed reaction parameters in each of the above test tubes on **structure** and **function** of Enzyme E2.

Reaction parameters	Effect on Enzyme E2	Is the effect reversible/ irreversible?
70°C in test tube #1	*Denaturation/Unfolding*	*Reversible – Can refold when temperature lowered back to 37°C*
10.4 pH in test tube #2	*Denaturation/Unfolding*	*Reversible - Can refold when pH is lowered back to 7.4*
Protease in Test tube #3	*Digestion/Degradation*	*Irreversible - the peptide bonds that hold the primary amino acid sequence of the enzyme are disrupted resulting in individual amino acids.*

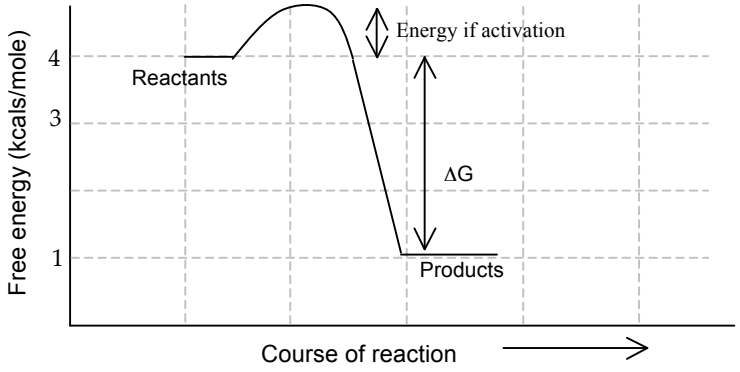
c) An enzyme may alter some or all of the following parameters. For each choose whether the enzyme would "increase" or "decrease" that parameter. If the enzyme does not affect that parameter, write "no change".

Parameter	Effect of enzyme
Free energy of the products	*no change*
Rate of forward reaction	*increase*
Rate of reverse reaction	*increase*
Energy of activation	*decrease*
Overall free energy change	*no change*

Question 2

a) On the axes below, draw and label the products and reactants, ΔG, and energy of activation for reaction 1 below.

1) A $\rightleftharpoons$ B, where the forward reaction has a $\Delta G = -3$, and an Energy of activation = +0.5



Compare reaction 1 (above) to reactions 2 and 3 (below).

2) C $\rightleftharpoons$ D, where the forward reaction has a $\Delta G = +2$, and an Energy of activation = +2.5
3) E $\rightleftharpoons$ F, where the forward reaction has a $\Delta G = +0.3$, and an Energy of activation = +2

b) Which of these reactions, 1, 2, or 3 is most likely to proceed in the forward direction in the absence of an enzyme? If you do not have enough information to answer this question, write *"Can't tell*" below. Explain your answer.
Reaction 1 is most likely to proceed in the forward direction in the absence of an enzyme because it is exergonic (the ΔG is negative) and the energy of activation is low compared to the other two reactions.

c) Which of these reactions, 1, 2, or 3 will have the larger K_{eq}? If you do not have enough information to answer this question, write *"Can't tell*" below. Explain your answer.
Reaction 1 will have a larger K_{eq}. *The free energy of the products is much less than the free energy of the reactants, thus the forward reaction is favored, and at equilibrium, there will be more products than reactants.*

d) Assume that you have a reaction X $\rightleftharpoons$ Y where $\Delta G = 0$ and the energy of activation = 0.6 kcal/mole. In a cell, you find that the reaction proceeds almost exclusively in the forward direction. Explain why this might be the case.
In a cell, the product can be used as soon as it is produced. This consumption of the product prevents the reverse reaction for occurring and drives the reaction in the forward direction.

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