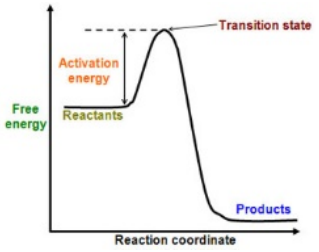
CONCEPT: ACTIVATION ENERGY



●*Energy of Activation* (E_A or $\Delta G^{\ddagger}$): energy barrier between substrates & transition state.

□ E_A controls *kinetics*; the _____ the E_A, the _____ it takes for a reaction to take place.

●*Question*: What factors contribute to the E_A barrier?

□ _____ factors primarily contribute to the E_A barrier:

1) _____ 2) Proper _____ of substrates 3) _____ of a substrate 4) _____

●*Binding energy* of an enzyme to its substrate influences each of these factors to _____ the E_A.

PRACTICE: Which of the following best describes the energy of activation for a reaction?

a) The difference in free energy between the substrate and product.
b) The difference in entropy between the substrate and transition state.
c) The difference in free energy between the substrate and the transition state.
d) The difference in entropy between the product and transition state.

1) Reducing Entropy & Random Motion

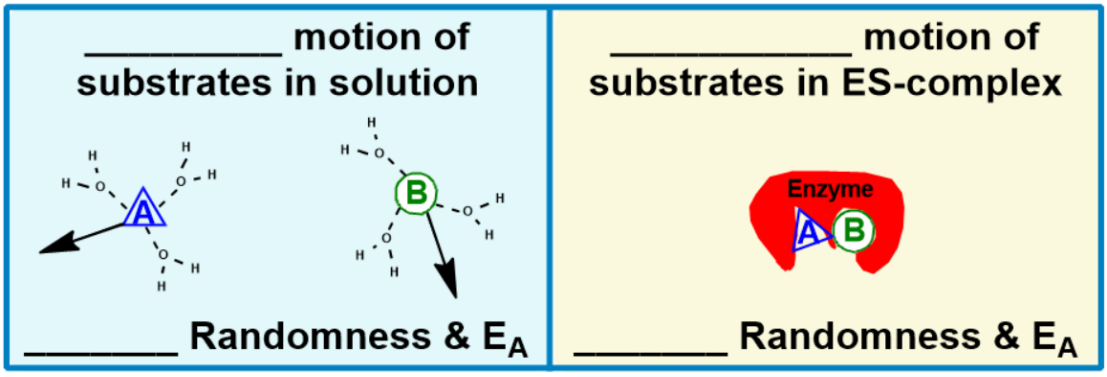
●Substrates in solution require collisions for reactions to take place but have lots of _____ motion (high entropy).

□ The _____ random motion, the _____ the likelihood of substrates colliding, which _____ the E_A.

●Enzymes _____ entropy of a reaction system by *restricting* random motion of substrates & bringing them *closer*.

□ Leads to increased likelihood of substrates reacting & a _____ E_A.

EXAMPLE: Enzymes Reduce Entropy.



PRACTICE: Which of the following best describes catalysis by proximity?

a) Catalysis by activation of the substrate through an interaction with an acidic amino acid.
b) Catalysis through enzyme-cofactor modification and a reduction in activation energy.
c) Catalysis through increasing the concentration of substrates in the enzyme active site.
d) Catalysis through physical distortion and strain on the substrate.

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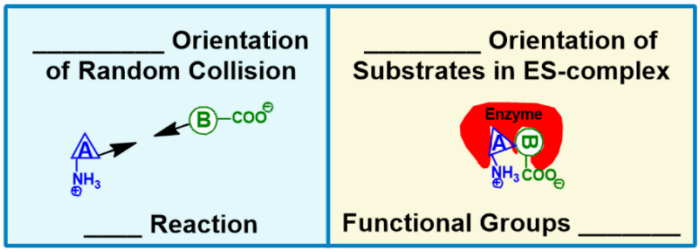
2) Proper Orientation of Substrates

●Not only do substrates in solution require a collision to react, they require collision in a proper _____.

□ Properly oriented random collisions between substrates in solution can be _____, which _____ E_A.

●Enzymes properly orient the _____ groups of substrates to make reactions *more* likely & *decrease* E_A.

EXAMPLE: Enzymes Properly Orient Substrates.



PRACTICE: Which of the following statements is false with respect to an enzyme's ability to catalyze a reaction?

a) An enzyme provides a reaction surface & suitable environment for a reaction to take place.

b) An enzyme binds substrates to position them correctly & allow them to attain transition state configurations.

c) An enzyme allows a reaction to go through a less stable transition state than normal.

d) a & c are false.

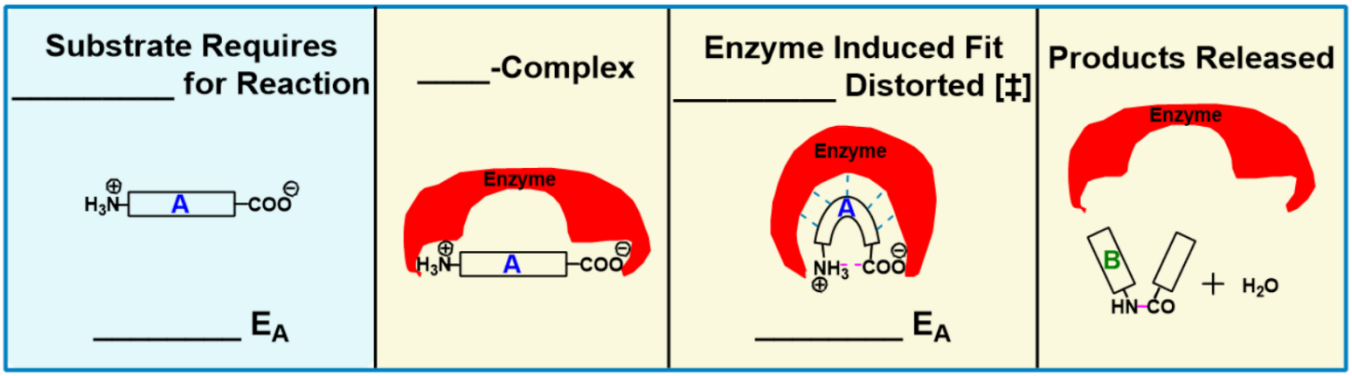
3) Distortion of a Substrate

●Many reactions require _____ of a substrate into an unstable/high-energy transition state (‡).

□ Distortion leads to an *increased* _____.

●_____ fit allows enzymes to form interactions with the ‡ and _____ distortions to *decrease* E_A.

EXAMPLE: Enzymes Stabilize ‡ Distortions.



PRACTICE: Which of the following is not a way that enzymes increase rates of reactions?

a) Binding of substrates in close proximity.

b) Covalently binding to the substrate.

c) Stabilization of the transition state.

d) Conformational changes in binding site slightly increases E_A.

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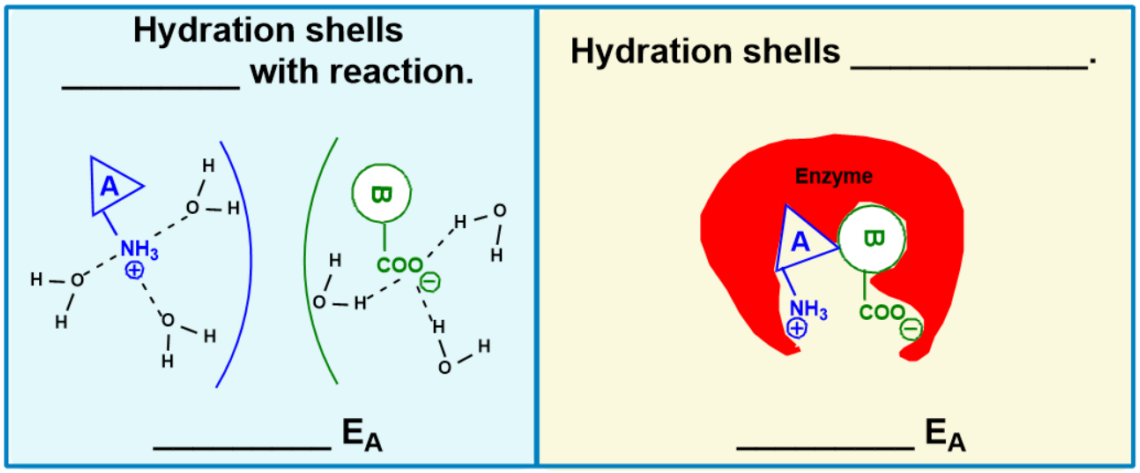
4) Solvation

●Solvation/hydration shells surrounding substrates in aqueous solutions can _____ with substrate reactions.

□ Interference *increases* _____ & *slows* reaction.

●Potentially interfering H_2O hydration shells are _____ with ES interactions.

EXAMPLE: Enzymes Desolvate Substrates.



PRACTICE: Binding energy between an enzyme and a substrate contributes to catalysis in which way?

a) Binding energy allows an enzyme to properly orient its substrates.

b) Binding energy contributions allow for entropy reduction in the ES-complex.

c) Binding energy compensates for energy changes as a result of desolvation of the substrate.

d) Binding energy contributes to the process of induced fit between the enzyme & the substrate.

e) a, b & c.

f) All the above are correct.

PRACTICE: Enzymes are potent catalysts because they:

a) Are consumed in the reactions they catalyze.

b) Are very specific and can prevent the conversion of products back to substrates.

c) Drive reactions to completion while other catalysts drive reactions to equilibrium.

d) Increase the equilibrium constants for the reactions they catalyze.

e) Lower the activation energy by stabilizing the transition states for the reactions they catalyze.