# Biochemistry 6

- iClicker 18A
- Energy and Bonds
- ΔG, activation energy, and rate
- Catalysts
- iClicker 18B

- Due in Lab this week
  - Pre-Lab 7 - GFP
  -
- Register your iClicker
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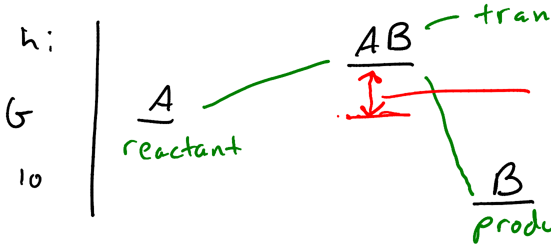
Review given a reaction $A \rightarrow B$ $\Delta G -$

∴ spontaneous (will occur)




transition state → intermediate b/t $A + B$

activation energy ($E_a$)

- determines rate
- molecules w/ $E > E_a$ react
- more molecules w/ $E > E_a$ → faster reaction

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Energy & Bonds

- breaking bonds requires energy input $\Delta G +$
- forming bonds releases energy $\Delta G -$

– if bonds in products are stronger than the bonds in reactants → $\Delta G$ – ∴ reaction is favored

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How to speed up a chemical reaction?

1. heat → higher average energy
2. lower $E_a$ → adding a catalyst

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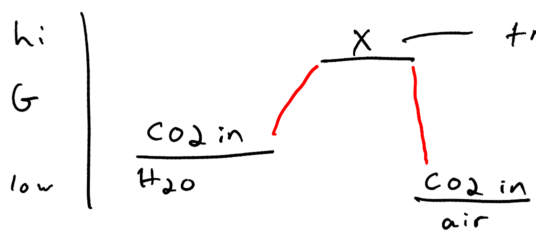
example making soda "fizz" (bubbles are $CO_2$)

2 states:
1. $CO_2$ dissolved in $H_2O$
2. $CO_2$ in air

- fizzy soda is mostly 1
- flat soda is mostly 2

1 → 2 is favored, but slow




transition state → tiny $CO_2$ bubbles surrounded by $H_2O$

reaction has a high $E_a$

– note: process is reversible → you can put fizz back into the soda, but $\Delta G$+ = requires energy input

how to increase rate?

- heat it up
- add catalyst – sugar

how does sugar catalyze 1 → 2?

- sugar has many cracks & holes on surface
- bubbles form in cracks & holes

easier for tiny bubbles to form larger bubbles

→ more molecules have $E > E_a$

→ results in faster reaction

note: physical catalyst, not chemical

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## Points about Catalysts

1. increase rate by changing reaction pathway
   - → reduces $E_a$ so more molecules have enough energy to transition
2. can <u>not</u> make $\Delta G+$ reactions happen
3. not permanently changed by the reaction
4. reaction-specific

# Bio 111 Thermodynamics II

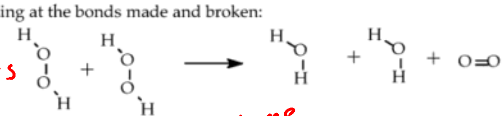
Today, we will be dealing with a chemical reaction that occurs both in the absence of living things and inside living cells. We will begin by looking at how the reaction proceeds without catalysis.

The reaction is the breakdown of two molecules of hydrogen peroxide ($H_2O_2$) into two molecules of water ($H_2O$) and one molecule of oxygen gas ($O_2$). This is a spontaneous reaction; you know this because hydrogen peroxide you buy at the drugstore 'goes bad' (breaks down) over time. Therefore:

$2\,H_2O_2 \Rightarrow 2\,H_2O + O_2$ $\Delta G$ - → favored → spontaneous reaction

Looking at the bonds made and broken:

reactants



products

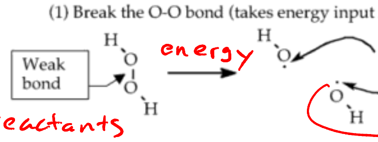
| Bonds at start | remain same | Bonds at end |
|---|---|---|
| 4 O-H | | 4 O-H |
| weak 2 O-O | | 1 O=O strong |

net: weak → strong
reactants → products
$\Delta G -$

So the net change is to break 2 O-O single bonds and replace them with one O=O double bond. Since O-O bonds are particularly weak (the lone pairs repel each other) and an O=O double bond is particularly strong, the $\Delta G$ for this reaction is negative.

Without a catalyst, this reaction proceeds in the following steps (simplified):

(1) Break the O-O bond (takes energy input $\Delta G$ +) **this is the TRANSITION STATE**:

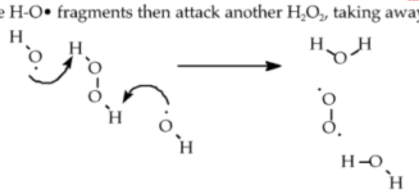



The single dots represent one electron each - they are each 1/2 of the bond

transition state

free radical = highly reactive

(2) The H-O• fragments then attack another $H_2O_2$, taking away 2 H•'s ($\Delta G$ ~ 0):



energy out

$\Delta G -$ → due to bond formation

(3) The ½ bonds (•) on the O-O join to form a second O-O bond ($\Delta G$-) to give the final products:

$O{=}O + 2\,H_2O$ — Strong bond

Biochemistry 7-2

Catalysts → made of protein → enzymes

- better than heat because they speed up specific reactions → body has control over reactions
- named "X ase" — X: specific to the reaction; ase: enzyme
- > 100,000 different enzymes, one for a different, specific reaction
- are essential to all living things

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ex. catalase → catalyzes breakdown of $H_2O_2$

$2\,H_2O_2 \xrightarrow{\text{catalase}} O_2 + 2\,H_2O$ $\Delta G -$

(substrate) (products)

$H_2O_2$ is toxic → your body needs to de-toxify $H_2O_2$

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how does catalase work?

- bonds to transition state (H-bonds)
- reduces $E_a$ -> lowers $\Delta G$ to reach transition state
- results in faster reaction

note: enzyme is not changed by the reaction

can do it over + over -> high rate