

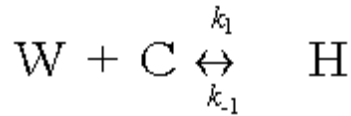
Textbook reading: Fersht, pp. 103-124

Read handout on numerical integration, and *practice it!*

Problem set #1

Due Wed., Sept 21

For her first lab in Biochem 1, brilliant student Karen Katastrophe is given two complementary DNA oligonucleotides: W (the "watson" strand) and C (the "crick" strand). She is told to dissolve these in a solution, each at the same concentration (call it concentration D for each), and then to guess at and experimentally test a mechanism by which the complementary oligos would dimerize to form a double helix (H). She guesses the following mechanism:



1. What will be the rate equations for W and for H governing Karen's scheme? (Denote the time-dependent concentrations as $w(t)$, $c(t)$, and $h(t)$, respectively.)
2. Convince yourself that conservation of mass demands that: $w(t)+c(t)+2h(t)=2D$. (In most kinetic problems you encounter, you will have to write down some sort of analogous relation.)
3. Solve the rate equations for the particular conditions pertaining to Karen's lab-assignment, i.e., $w(0) = c(0) = D$, $h(0)=0$, and in addition assume the special case $k_{-1} = 0$. Show that your solution is correct by differentiating it with respect to t and plugging the solution and its derivative back into the rate equation.
4. By numerical integration using a spreadsheet program, make two graphs that show the concentrations of W and H as a function of time for the parameter values:
 $k_1 = 10^6 \text{ M}^{-1} \text{ s}^{-1}$, $k_{-1} = 0$, $D = 5 \text{ } \mu\text{M}$, and $h(0) = 0$
 Make certain that the decay time of the curve is of the correct order of magnitude, given the rate constants and initial concentrations. Explain your reasoning.
5. Suppose that Karen does this experiment again, but now with a totally different set of initial conditions, where C is in 100-fold excess over W, so that the concentration of C remains essentially constant during the dimerization. Obtain an algebraic expression for the formation of double helix, $h(t)$, still assuming that $k_{-1} = 0$. Are you surprised in comparing the timecourse here with that in prob (2)?
6. Now suppose that Karen starts out with a sample of the same oligos in double-helical form, except that now the reverse rate constant of dissociation, k_{-1} , is not zero. She throws this into solution at an initial concentration $h(0)$ and watches the reaction proceed to equilibrium. Set up and simplify as much as possible the differential equation for $h(t)$ describing this situation. Don't try to solve it (but stare at it enough to see why it requires techniques you probably don't know.) Instead, use a spreadsheet program to see what the timecourse looks like, given:

$$k_1 = 10^6 \text{ M}^{-1} \text{ s}^{-1}, k_{-1} = 5 \text{ s}^{-1}, h(0) = 3 \text{ } \mu\text{M}. \quad \text{Does this make sense?}$$