Please show your work as this will make it easier to give partial credit. Also, don't round numbers so severely that the selection disappears! (You will probably need at least 4 digits after the decimal point for this HW.)

The enzyme alcohol dehydrogenase (ADH) is used by fruit flies (and people) to detoxify alcohol. Without it, alcohol can cause fatal poisoning. Call the wild-type, working version of the gene $ADH+$ and a broken, non-working copy $ADH-$.

1. Suppose that we raise fruit flies on carefully sterilized food so that they do not encounter any alcohol, and the ADH enzyme is not needed.
   (a) If the mutation rate from working $ADH+$ to broken $ADH-$ is 10^{-7} and from $ADH-$ back to $ADH+$ is 10^{-9}, what will be the long-term equilibrium frequency of $ADH+$? (Ignore the possibility of multiple mutations in the same copy.)
   (b) Will this happen quickly? Why or why not?
2. We have managed to breed a population of lab flies which have allele frequencies as follows:

$ADH+$	0.7
$ADH-$	0.3

   (a) What will the genotype frequencies be in our population, assuming it is in Hardy-Weinberg equilibrium?
   (b) We now release adult flies into the cafeteria, where their main food source is alcohol-rich spoiled fruit. Their fitnesses are as follows:

Genotype	$+/+$	$+/-$	$-/-$
Fitness	1.0	1.0	0.4

   After one generation, what genotype frequencies do we expect in adult flies? (Assume that alcohol poisoning kills larvae, so that by the time the flies are adults, all of the deaths due to selection have happened.)
   (c) What allele frequencies will be present in adults of this new generation?
   (d) If we sample 1000 adult flies and they conform exactly to the post-selection genotype frequencies and allele frequencies you computed in the previous two subquestions, will they be significantly different from H-W at the 5% level? (Round fractional flies so as to keep the total at 1000.) Please show your χ^2 table, and use the post-selection allele frequencies to calculate expectations, not the allele frequencies from the original release population.
   (e) After a few million years in the cafeteria, what is the expected allele frequency of $ADH-$? (Assume the population is very large.)
3. A new mutation of ADH, which we will call $ADH*$, arises in our cafeteria. It is dominant, and flies with at least one copy benefit from a super-active ADH protein which gives them a 10% advantage (in the cafeteria environment) over wild-type $ADH+/ADH+$.
   (a) Write out fitnesses for each genotype found in a population with all three alleles present. Set the fitness of the most fit genotype to 1.0.
   (b) If the pre-selection frequencies of the three alleles are as shown below, what will the post-selection frequencies be?
   $ADH+$ 0.9
   $ADH-$ 0.09
   $ADH*$ 0.01

   (c) Will $ADH*$ zoom straight to fixation (allele frequency of 1.0) or will it slow down eventually? Explain briefly.