

Name:

**Chemistry 153B – Winter 2026
Midterm 1**

I understand that academic integrity is highly valued at UCLA. Further, I understand that academic dishonesty, such as cheating and plagiarism, are violations of university policy and will be pursued by the appropriate campus administrator. Finally, my signature below signifies that the work included is my own, and that I completed this assignment honestly.

NAME:

UID:

Signature:

Question 1 (13 pts):

Question 2 (6 pts):

Question 3 (2 pts):

Question 4 (3 pts):

Question 5 (21 pts):

Question 6 (26 pts):

Question 7 (29 pts):

Cheat sheet (1 point extra credit):

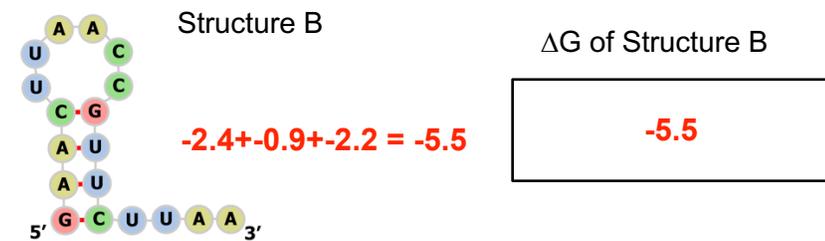
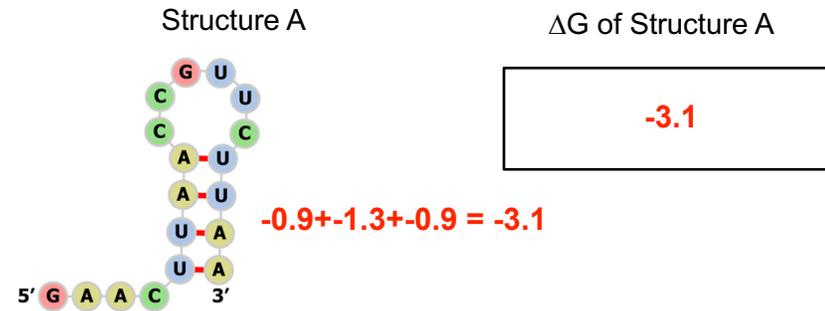
Name:

Question 5 (21 pts). Scientists are interested in the structure of the following RNA sequence:

5' -GAACUUAACCGUUCUUA-3'

Sequence	ΔG (kcal/mol)
5' AA 3' 3' UU 5'	-0.9
5' AU 3' 3' UA 5'	-1.1
5' UA 3' 3' AU 5'	-1.3
5' CU 3' 3' GA 5'	-2.1
5' CA 3' 3' GU 5'	-2.1
5' GU 3' 3' CA 5'	-2.2
5' GA 3' 3' CU 5'	-2.4
5' CG 3' 3' GC 5'	-2.4
5' GG 3' 3' CC 5'	-3.3
5' GC 3' 3' CG 5'	-3.4

5.1 (6 pts) Using the table of nearest neighbor energies on the left, calculate the free energies (ΔG) of each of these two possible secondary structures (the red lines indicate base pairs):



5.2 (2 pts) Based on your calculated free energies, if you experimentally determined this structure, which conformation would you be more likely to observe (A or B)?

B

5.3 (3 pts) Would the base-paired region of this sequence most likely adopt an A-form or B-form helical conformation, and why?

A-form. RNA adopts a C3' endo sugar pucker, which causes the A-form conformation. RNA does not adopt B-form due to its C3' endo sugar pucker.

5.4 (3 pts) Why is the free energy of 5' GG 3' / 3' CC 5' lower than the free energy of 5' AA 3' / 3' UU 5' ?

Stacking of G-C pairs tends to be more favorable than stacking of A-U pairs

5.5 (3 pts) Protein RBPX binds to internal loops that contain the sequence 5'-RNUU-3'. Underline all 5'-RNUU-3' sequences in this RNA sequence (regardless of whether they are in an internal loop or not).

5' -GAACUUAACCGUUCUUA-3'

5.6 (2 pts) If the RNA folded into secondary structure A, is it likely that protein RBPX would bind to this RNA sequence? (yes or no)

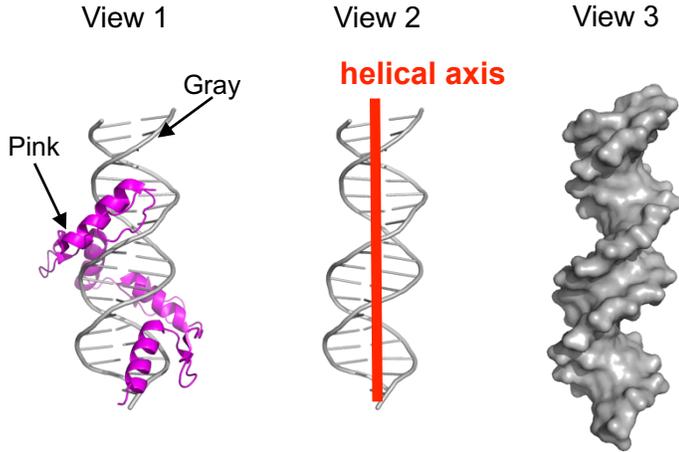
No

5.7 (2 pts) If the RNA folded into secondary structure B, is it likely that protein RBPX would bind to this RNA sequence? (yes or no)

No

Name:

Question 6 (26 pts). Scientists have determined the structure of a nucleic acid duplex bound to a protein, shown below in three different views. View 1 shows both the protein (pink) and nucleic acid duplex (gray). The nucleic acid duplex is shown from the same orientation in View 2 and View 3, but the protein is hidden.



6.1 (2 pts) Does the nucleic acid duplex adopt a left-handed or right-handed helix?

Right

6.2 (2 pts) Draw and label the helical axis on the View 2 image.

6.3 (2 pts) What helical conformation does the nucleic acid duplex most closely resemble (A-form, B-form, or Z-form)?

B-form

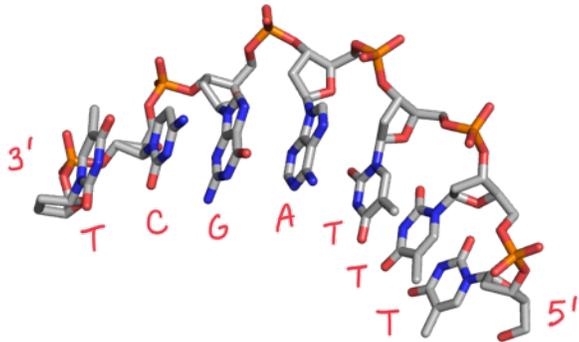
6.4 (2 pts) Based *only* on the image above, is the

DNA

nucleic acid duplex most likely DNA, RNA, or is it equally likely that it could be DNA or RNA?

6.5 (3 pts) Based only on the images above, is it likely that this protein is sequence-specific? Why or why not?

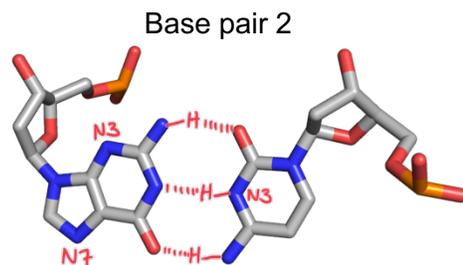
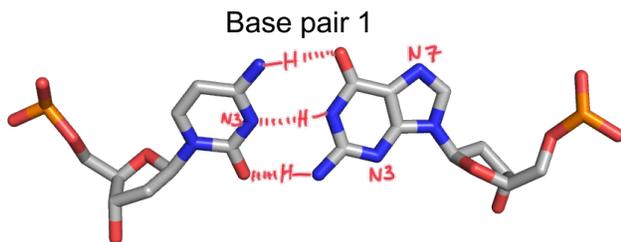
Yes, the protein binds in the major groove where it would be able to make sequence-specific hydrogen bonds.



6.6 (5 pts) One piece of the nucleic acid duplex is shown on the left. Carbon atoms are colored gray, oxygen atoms are colored red, nitrogen atoms are colored blue, and phosphorus atoms are colored orange. Write out the sequence of this nucleic acid from 5' to 3' using the one letter code for nucleotides (A, C, G, T, U) and denoting the sugar.

5'-d(TTTAGCT)-3'

6.7 (6 pts) One of the two base pairs shown below comes from the protein-nucleic acid duplex structure above. The other base pair comes from an unrelated structure. Draw the hydrogen bonds, including the hydrogens that are involved, in each. Label the N3 and N7 atoms in both base pairs.

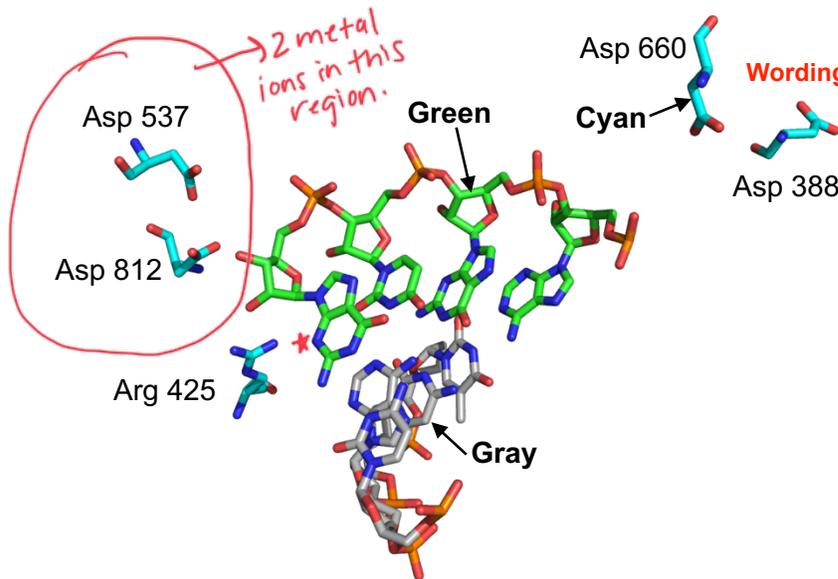


6.8 (4 pts) Which base pair shown above is most likely to have come from the protein-nucleic acid duplex structure above? Give one reason why the other base pair is unlikely to have come from the structure above.

Base pair 1. In base pair 2, the G is in the syn conformation, which is not normal for B-form DNA (nucleotides in B-form are usually all in the anti conformation).

Name:

Question 7 (29 pts). Scientists have solved the structure of a polymerase after it has undergone a few rounds of polymerization. One view of the structure is shown below. The carbon atoms in the template strand are colored gray. The carbon atoms in the primer strand are colored green. A few amino acids from the polymerase are shown with their carbon atoms colored cyan (the remainder of the polymerase structure is not shown). Oxygen atoms are red, nitrogen atoms are blue, and phosphorus atoms are orange.



Oxygen atoms are red, nitrogen atoms are blue, and phosphorus atoms are orange.

7.1 (3 pts) Based on what you can see in the image, is this an RNA polymerase or a DNA polymerase?

RNA

7.2 (3 pts) On the image, draw a star to the left of the N3 atom of the nucleotide that the polymerase most recently added to the primer.

7.3 (6 pts) On the image, draw circles approximately where you'd expect to see two important metal ions. In the box below, list two important functions the metal ions would perform.

- 1: Any 2 of the following are OK:
Lowering the pKa of the 3'O to activate the 3' OH for attack on the alpha phosphate of the incoming NTP
- 2: Stabilize the structure and charge of the pentavalent transition state
Stabilize the negative charge on the leaving group

7.4 (6 pts) Which of the labeled Asp residues in the image likely play a critical role in the catalytic activity of this polymerase? What is one important role that these Asp residues likely play? Explain in one sentence.

Asp residues: **537, 812**

Explain one likely important role: **Positioning two metal ions**

7.5 (4 pts) Based on what is shown in the image above, would you expect that this polymerase is capable of adding both dNTPs **and** rNTPs to the growing primer strand? Ignore whether the polymerase might *prefer* one over the other. If the polymerase can only add dNTPs **or** rNTPs, state which one. Explain.

The polymerase could add either dNTPs or rNTPs — there is nothing in the structure that we see above that would preclude one or the other (no steric gate).

7.6 (4 pts) Based on what is shown in the image above, describe any differences in the interactions the polymerase could make with incoming rNTPs compared to dNTPs. If there are no differences, write N/A.

Incoming rNTPs can form a hydrogen bond with Arg425 (Arg425 donates a hydrogen bond to the 2'OH of an rNTP). This hydrogen bond would not be possible for a dNTP, which would lack a 2'OH.

7.7 (3 pts) Suppose that a polymerase doesn't have any structural mechanism to discriminate between incoming dNTPs and rNTPs. In a cell, which would more frequently end up in the active site: dNTPs or rNTPs? Explain in one sentence.

rNTPs would more frequently end up in the active site. In a cell, rNTPs are found at much higher concentrations than dNTPs.

WRITE YOUR ANSWERS IN THE BOXES. ANSWERS OUTSIDE OF THE BOXES WILL BE IGNORED.