

Student Name : \_\_\_\_\_

2014-03-14

Student ID : \_\_\_\_\_

**Instructions:**

Write neatly and clearly. Cross out with a single line any material you do not wish to have marked. Marks will be deducted for incorrect statements. Students must work independently and may not knowingly utilize resource materials or share resource materials with other students. Students may use pens, pencils, erasers and calculators only.

Electronic devices including cell phones, personal information managers and audio devices are prohibited.

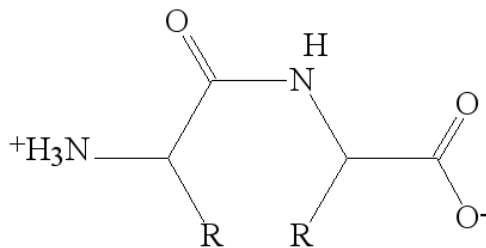
<b>Question</b>	<b>Mark</b>	<b>Total Marks</b>
<b>1</b>	52%	10
<b>2</b>	57%	5
<b>3</b>	40%	9
<b>4</b>	48%	6
<b>5</b>	47%	6
<b>Total</b>	48.4%	<b>36</b>

(1) In the space provided, give brief definitions or unique descriptions of the following terms: (10 marks)

- (a) Hydrogen Bond – Interaction between a potential acid and potential base at a distance less than the sum of their atomic radii.
- (b)  $\alpha/\beta$  fold – domain fold containing  $\alpha$ -helices and parallel  $\beta$ -sheets
- (c)  $v_o$  - intial velocity of a reaction
- (d)  $\Delta\Delta G^\ddagger$  - difference in free energy change for catalyzed and uncatalyzed reactions.
- (e) 'Equilibrium Assumption' – when  $k_{-1} \gg k_2$ , substrate binding reaches equilibrium before product is formed

(2) Draw the following structures: (5 marks)

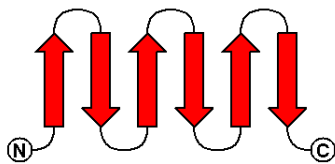
- (a) A stick diagram of a dipeptide (use R for the side chain) with a *cis* peptide bond at pH 4.



2 marks for *cis*-peptide

1 mark for dipeptide structure/charge

- (b) A topology diagram for an “up and down  $\beta$  barrel” consisting of 6  $\beta$  strands.



Topology diagrams are 2D so barrel and open-sheet structures are identical

1 mark for antiparallel and 1 mark for 6 strands

(3) Michaelis-Menten Kinetics (9 marks):

- (a) Consider an enzyme with a  $k_{cat} = 4 \text{ s}^{-1}$  and  $K_M = 1 \mu\text{M}$ . Calculate the substrate concentration at which the initial velocity of the enzyme is  $1/4 V_{max}$ . (Provide both your calculation and the end result.)

$$v_o = V_{max} [S] / (K_M + [S])$$

$$\text{When } v_o = V_{max}/4 ; \quad V_{max}/4 = V_{max} [S] / (K_M + [S])$$

$$\text{Simplifying ;} \quad 1/4 = [S] / (K_M + [S])$$

$$\text{Solving for [S] ;} \quad [S] = K_M/3$$

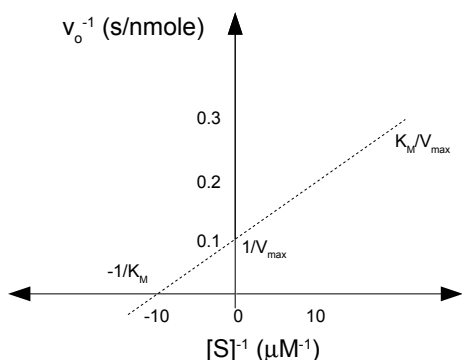
$$\text{Given } K_M = 1 \mu\text{M}; \quad [S] = 0.33 \mu\text{M at } 1/4 V_{max}$$

(b) For a Michaelis-Menten reaction of an enzyme C (different from the ones in question a),  $k_1 = 1 \times 10^6 \text{ M}^{-1} \text{ s}^{-1}$ ,  $k_{-1} = 5 \times 10^5 \text{ s}^{-1}$ , and  $k_2 = 5 \times 10^1 \text{ s}^{-1}$ . Calculate the  $K_M$  for this reaction. Does substrate binding achieve equilibrium? Explain your answer.

$$K_M = (k_{-1} + k_2) / k_1 = (5 \times 10^5 \text{ s}^{-1} + 5 \times 10^1 \text{ s}^{-1}) / 1 \times 10^6 \text{ M}^{-1} \text{ s}^{-1} = \underline{0.5 \text{ M}^{-1}}$$

Yes, since both  $k_{-1}$  (and  $k_1$ ) are much larger than  $k_2$ .

(c) Draw a reasonable Lineweaver-Burke Plot for an enzyme with  $K_M = 0.1 \text{ } \mu\text{M}$  and  $V_{\max} = 10 \text{ nmoles/min}$ . Carefully label the axis and how the plot indicates the above kinetic parameters.



1 mark for each labeled axis (2 total)

1 mark each for slope and intercepts (3 total)

(4) Answer the following questions. (6 marks)

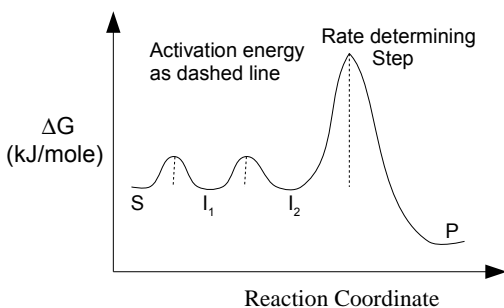
(a) Why have proteins (and RNA-protein complexes) evolved quaternary structures (*i.e.* What are the advantages of quaternary structure)?

1- facilitate the assembly of large macromolecular complexes

2- protein polymorphism

3- novel regulatory mechanisms (eg. Allostery, cooperativity)

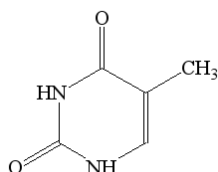
(b) Draw and label a reaction coordinate diagram for an overall reaction composed of three elementary steps. The third elementary step is rate-limiting.



1 mark each for axis labels, 3 steps, and rate determining step.

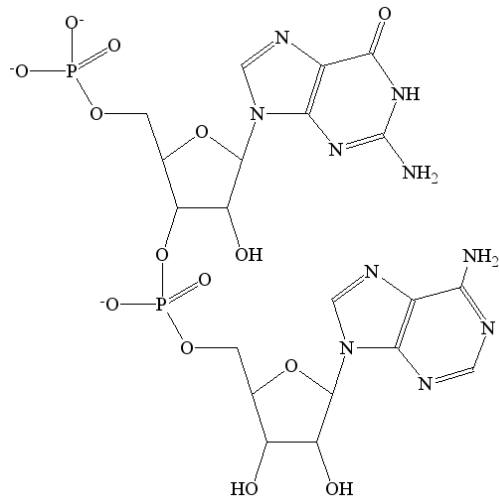
(5) Answer the following questions: (6 marks)

(a) Give a proper name for the following structure.



Thymine

(b) Draw a stick diagram of pGpA



1 mark for each base, each phosphate and 1 mark for both ribose rings (5 total)