Chemistry 2713 Name: _____

Biochemistry Student Number: _____

Winter 2018

Midterm Exam #2

Answer all questions on the test. Each multiple choice question has a value of two points and must be answered in pencil on the bubble sheet provided. The value for each short answer question is given with the questions.

The final two pages of the exam have equations and other relevant information. Feel free to remove these pages, but the rest of the midterm and the bubble sheet must be submitted to receive marks for all questions.

Programmable calculators are not allowed. You may use a molecular model kit.

1																	18
1 H 1.008	2											13	14	15	16	17	2 He 4.003
3 Li 6.941	4 Be 9.012											5 B 10.81	6 C 12.01	7 N 14.01	8 O 16.00	9 F 19.00	10 Ne 20.18
11 Na 22.99	12 Mg 24.30	3	4	5	6	7	8	9	10	11	12	13 Al 26.98	14 Si 28.09	15 P 30.97	16 S 32.06	17 Cl 35.45	18 Ar 39.95
19 K 39.10	20 Ca 40.08	21 Sc 44.96	22 Ti 47.87	23 V 50.94	24 Cr 52.00	25 Mn 54.94	26 Fe 55.84	27 Co 58.93	28 Ni 58.69	29 Cu 63.55	30 Zn 65.38	31 Ga 69.72	32 Ge 72.64	33 As 74.92	34 Se 78.96	35 Br 79.90	36 Kr 83.80
37 Rb 85.47	38 Sr 87.62	39 Y 88.91	40 Zr 91.22	41 Nb 92.91	42 Mo 95.96	43 Tc (98)	44 Ru 101.1	45 Rh 102.9	46 Pd 106.4	47 Ag 107.9	48 Cd 112.4	49 In 114.8	50 Sn 118.7	51 Sb 121.8	52 Te 127.6	53 I 126.9	54 Xe 131.3
55 Cs 132.9	56 Ba 137.3	57 La 138.9	72 Hf 178.5	73 Ta 180.9	74 W 183.8	75 Re 186.2	76 Os 190.2	77 Ir 192.2	78 Pt 195.1	79 Au 197.0	80 Hg 200.6	81 Tl 204.4	82 Pb 207.2	83 Bi 209.0	84 Po (209)	85 At (210)	86 Rn (222)
87 Fr (223)	88 Ra 226.0	89 Ac 227.0	104 Rf (265)	105 Db (268)	106 Sg (271)	107 Bh (270)	108 Hs (277)	109 Mt (276)	110 Ds (281)	111 Rg (280)	112 Cn (285)	113 Nh (284)	114 Fl (289)	115 Mc (288)	116 Lv (293)	117 Ts (294)	118 Og (294)

Multiple Choice		/80
Structure Drawing		/30
Bonus		/5
Total		/110

Question 1
A living organism is what type of thermodynamic system?

a. at equilibrium
b. at work
c. closed
d. open
e. static

Question 2
Which of the following statements is true of an open system?

a. there is an exchange of energy only with the surroundings
b. there is an exchange of matter only with the surroundings
c. there is an exchange of both matter and energy with the surroundings
d. either matter or energy, but not both may be exchanged with the surroundings
e. energy flows only into the system: matter flows out of the system

Question 3
Which of the following is not a standard condition for standard free energy?

a. 25 °C
b. 1 atm pressure
c. concentration of reactants = 1.0 M
d. concentration of products = 1.0 M
e. pH = 7

Question 4
For a reaction to be spontaneous which of the following statements must be true?

a. $\Delta S_{univ} = 0$
b. $\Delta \boldsymbol{S_{univ}}$ = positive
c. ΔS_{univ} = negative
d. A or B
e. entropy has no effect on the spontaneity of a process

Question 5
The most important direct source of energy in the body is:

a. ADP
b. adenosine
c. amino acids
d. ATP
e. glucose

Question 6
An organism at equilibrium is said to be _____.

a. at rest
b. dead
c. dormant
d. hibernating
e. sleeping

Question 7
For two reactions to be coupled what conditions must be met?

a. both reactions must be spontaneous
b. neither reaction can be spontaneous
c. a product of one of the reactions must be a reactant in the second reaction
d. both reactions must have ATP as a reactant
e. they must have common products

Question 8
Which of the following processes are driven by the hydrolysis of ATP?

a. active transport across membranes
b. biosynthesis of biomolecules
c. mechanical work such as muscle contraction
d. A and C are correct
e. A, B and C are correct

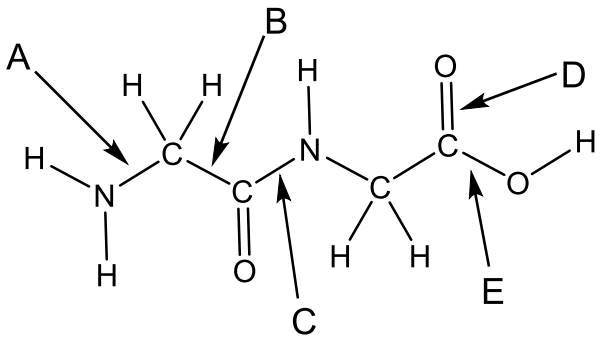
Question 9
The products of the hydrolysis of ATP are more stable than ATP itself. This circumstance is due to?

a. pH effects
b. relief of charge-charge repulsions
c. resonance stabilization of the products
d. B and C are correct
e. A, B and C are correct

Question 10
What type of bond is being cleaved during the conversion of ATP to ADP?

a. alcohol
b. anhydride
c. amide
d. ester
e. ether

Question 11
Consider the following dipeptide. Which letter indicates a peptide bond?



a. A
b. B
c. C
d. D
e. E

Question 12
The term protein refers to amino acid polymers with greater than _____amino acids.

a. 10
b. 25
c. 50
d. 75
e. 100

Question 13
Which of the following amino acids is not chiral?

a. alanine
b. glycine
c. leucine
d. proline
e. valine

Question 14
Which of the following would be classified as a nonstandard amino acid?

a. asparagine
b. cysteine
c. glycine
d. 5-hydroxyproline
e. valine

Question 15
Which of the following is a polar amino acid?

a. methionine
b. phenylalanine
c. proline
d. tryptophan
e. tyrosine

Question 16
Which of the following is a basic amino acid?

a. arginine
b. asparagine
c. glutamine
d. threonine
e. tryptophan

Question 17
The 21st proteinogenic amino acid is:

a. selenocysteine
b. selenomethionine
c. selenoserine
d. selenothreonine
e. selenotyrosine

Question 18
The three-letter abbreviation for tryptophan is:

a. Thr
b. Tph
c. Trp
d. Try
e. Tyr

Question 19
The three-letter abbreviation for glutamine is:

a. Gla
b. Gle
c. Gln
d. Glt
e. Glu

Question 20
The one-letter abbreviation for lysine is:

a. L
b. K
c. Q
d. S
e. Y

Question 21
The one-letter abbreviation for glutamic acid is:

a. E
b. G
c. L
d. M
e. U

Question 22
When the identity of an amino acid cannot be distinguished between asparagine and aspartate, the three-letter abbreviation for the ambiguous residue is:

a. Agt
b. Ape
c. Apt
d. Asp
e. Asx

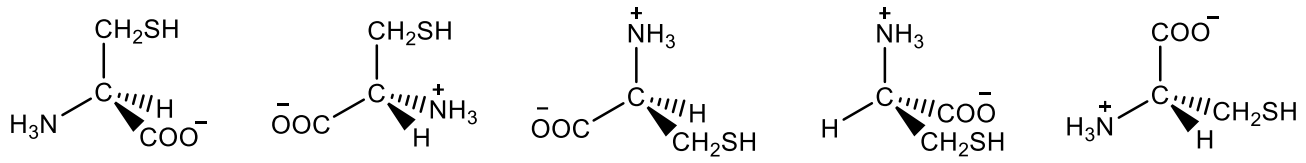
Question 23
Which of the following is an essential amino acid?

a. arginine
b. cysteine
c. methionine
d. proline
e. serine

Question 24
Which of the following is *not* an essential amino acid?

a. isoleucine
b. lysine
c. phenylalanine
d. tryptophan
e. tyrosine

Question 25
Which of the following depictions of cysteine is not in its naturally occurring L form?

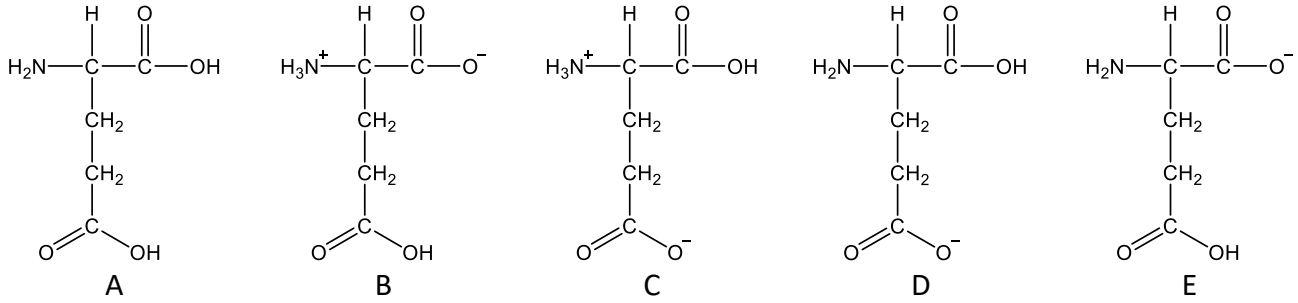


a. A
b. B
c. C
d. D
e. E

Question 26
What is the isoelectric point for serine?

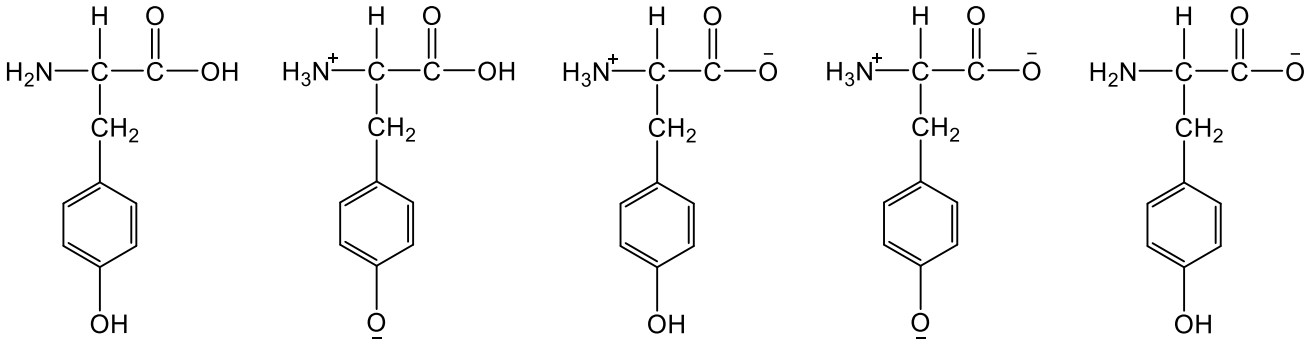
a. 4.26
b. 5.59
c. 6.92
d. 7.00
e. 11.18

Question 27
Which of the following structures is the principal form of glutamic acid at its isoelectric point?



a. A
b. B
c. C
d. D
e. E

Question 28
Which of the following structures is the principal form of tyrosine at pH 10?



a. A
b. B
c. C
d. D
e. E

Question 29
What is the isoelectric point for cysteine?

a. 5.03
b. 6.10
c. 7.00
d. 8.14
e. 9.21

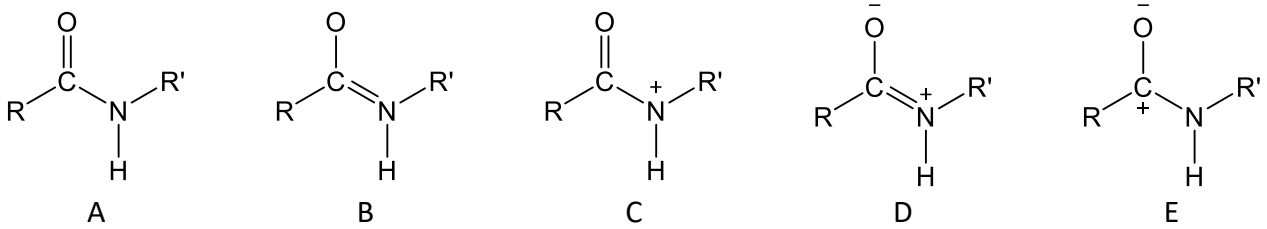
Question 30
When not at the terminal of a protein which of the following amino acids cannot contribute to the pI of a protein?

a. alanine
b. arginine
c. cysteine
d. lysine
e. tyrosine

Question 31
If a dipeptide has an isoelectric point of 5.72, in which direction will the dipeptide move at pH 5?

a. does not move
b. towards the anode
c. towards the cathode
d. towards both the anode and the cathode
e. need more data

Question 32
Which structure best represents the actual structure of a peptide bond?



a. A
b. B
c. C
d. D
e. E

Question 33
What is the isoelectric point of the tripeptide H_3N^+–Val–Pro–Trp–COO^-?

a. 5.80
b. 5.90
c. 5.95
d. 5.99
e. 6.21

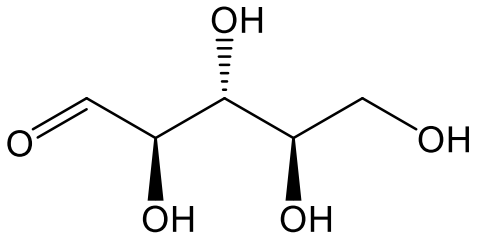
Question 34
What is the isoelectric point of the tripeptide H_3N^+–Gly–Lys–Ser–COO^-?

a. 5.70
b. 5.86
c. 6.40
d. 9.86
e. 10.12

Question 35
What is the net charge of the tripeptide H_3N^+–Ala–Asp–Tyr–COO^- at pH 4?

a. positive
b. negative
c. neutral
d. infinite
e. need more information to answer

Question 36
What are the absolute stereochemistry designations (i.e., R and S) for each chiral centre from left to right for the isomer of ribose shown?



a. R, R, R
b. R, S, R
c. S, R, S
d. S, R, R
e. S, S, S

Question 37
Given the following Δ*H* values calculate the Δ*H* for the complete combustion of sucrose.

Compound	Δ*H* (kJ mol^{-1})
$C_{12}H_{22}O_{11}$	–2222
O_2	0
CO_2	–393.3
H_2O	–286.2

a. –1542 kJ mol^{-1}
b. –2822 kJ mol^{-1}
c. –2902 kJ mol^{-1}
d. –5646 kJ mol^{-1}
e. –8794 kJ mol^{-1}

$$C_{12}H_{22}O_{11} + 12\ O_2 \rightarrow 12\ CO_2 + 11\ H_2O$$

$$\Delta_c H = \sum \Delta_f H(products) - \Delta_f H(reactants)$$
$$\Delta_c H = [12(-393.3) + 11(-286.2)] - [1(-2222) + 12(0)]$$
$$\Delta_c H = [(-4719.6) + (-3148.2)] - [(-2222) + (0)]$$
$$\Delta_c H = [-7867.8] - [-2222] = -5645.8 kJ \cdot mol^{-1}$$

Question 38
Assume that the complete combustion of glucose to carbon dioxide and water liberates 2870 kJ mol^{-1} (*i.e.*, $\Delta G^{\circ\prime} = -2870$ kJ mol^{-1}). If one contraction cycle in muscle requires 45 kJ, and the energy from the combustion of glucose is converted with an efficiency of 47% to contraction, how many contraction cycles could be fuelled by the complete combustion of one mole of glucose (180.16 g mol^{-1})?

a. 16
b. 22
c. 30
d. 64
e. 136

$$(2870\ kJ \cdot mol^{-1})(1\ mol) \times 0.47 = 1348.9\ kJ$$

$$\frac{1349\ kJ}{45\ kJ/cycle} = 30\ cycles$$

Question 39
If $\Delta G^{\circ\prime}$ for the hydrolysis of phosphocreatine is –43.1 kJ mol^{-1}, what is the free energy at body temperature (37 °C) if the concentration of phosphocreatine is 6.9 M and the concentration of creatine (the hydrolyzed product) is 1.3 M?

a. –38.8 kJ mol^{-1}
b. –39.6 kJ mol^{-1}
c. –42.4 kJ mol^{-1}
d. –43.6 kJ mol^{-1}
e. –47.4 kJ mol^{-1}

$$\Delta G' = \Delta G^{\circ\prime} + RT \ln \frac{[products]}{[reactants]}$$

$$\Delta G' = -43.1 + (8.314 \times 10^{-3} kJ \cdot mol^{-1} \cdot K^{-1})(37 + 273K) \ln \frac{1.3}{6.9}$$

$$\Delta G' = -43.1 + (-4.3) = -47.4$$

Question 40

Consider the following reaction in which the sugar fructose reacts with ATP to form fructose-6-phosphate:

$$\text{ATP + Fructose} \rightarrow \text{ADP + Fructose-6-phosphate}$$

What is the equilibrium constant (K_{eq}) for the reaction at 25 °C given the following free energy values for the two half reactions:

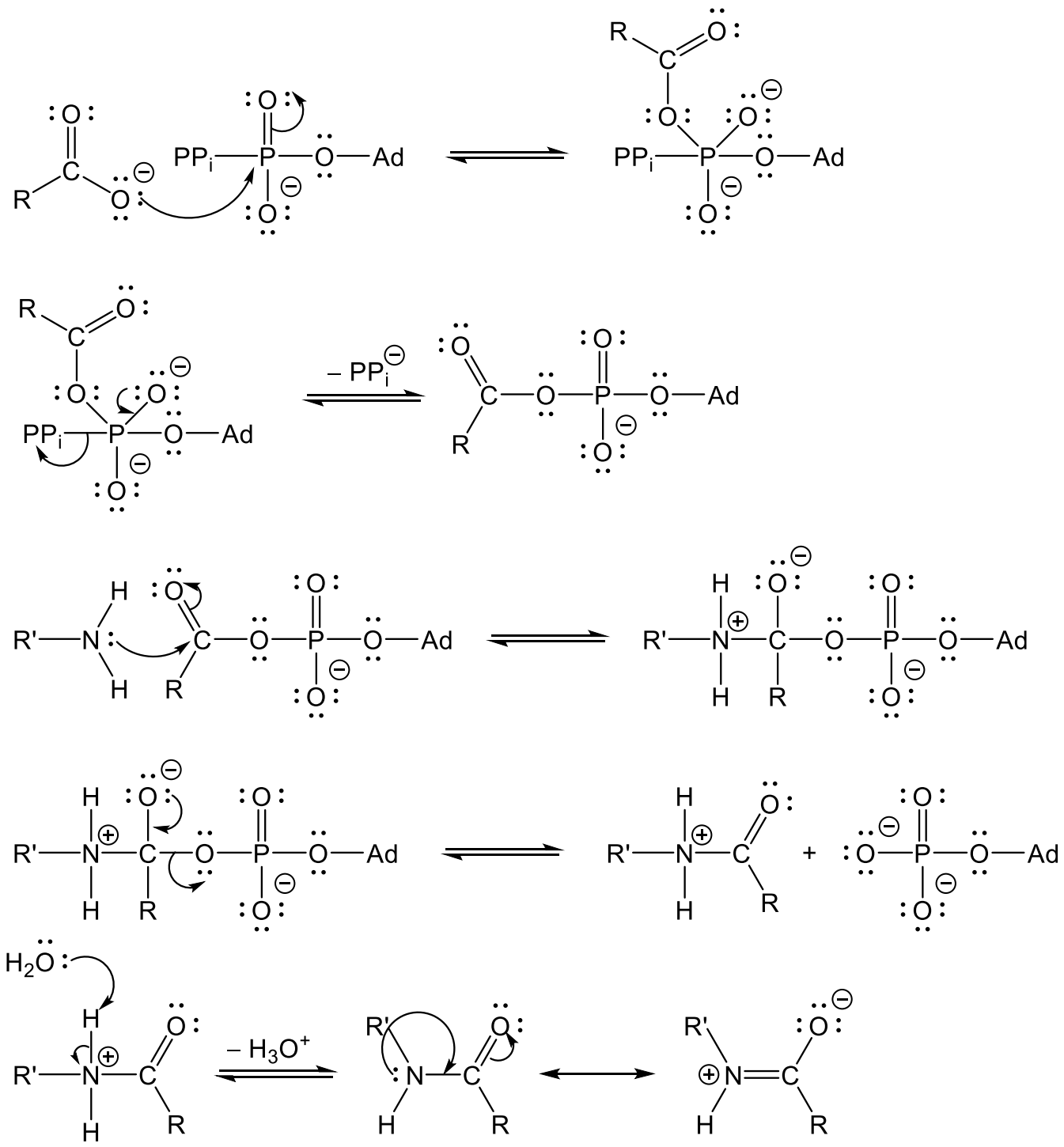
	$\Delta G^{\circ\prime}$ (kJ mol^{-1})
$ATP + H_2O \rightarrow ADP + P_i$	–30.5
$Fructose + P_i \rightarrow Fructose\text{-}6\text{-}phosphate + H_2O$	+15.9

a. 2.76×10^{-3}
b. 1.01
c. 14.6
d. 362
e. 7.81×10^{5}

$$\Delta G^{\circ\prime(overall)} = \Delta G_1^{\circ\prime} + \Delta G_2^{\circ\prime} = -30.5 + 15.9 = -14.6$$

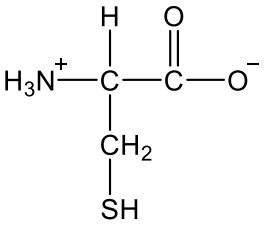
$$\Delta G^{\circ\prime} = -RT \ln K$$
$$-14.6 = -(8.314 \times 10^{-3} kJ \cdot mol^{-1} \cdot K^{-1})(25 + 273K) \ln K$$
$$-14.6 = -2.478 \ln K$$
$$5.893 = \ln K$$
$$K = e^{5.893} = 362$$

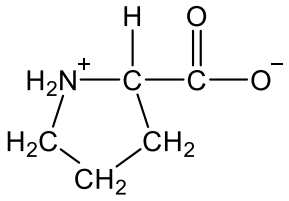
Question 41 (10 points)
The following scheme depicts the mechanism for peptide bond formation. Complete the mechanism by adding charges, small molecules and curved arrows.

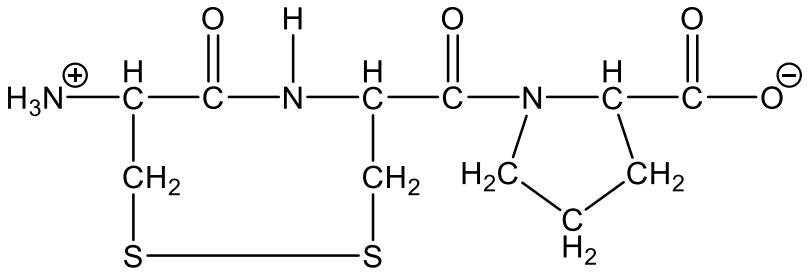


12 × arrow = 12 × 0.5 = 6 pts
20 × charge = 20 × 0.15 = 3 pts
2 × small molecule (PP_i^- and H_2O) = 2 × 0.5 = 1 pt

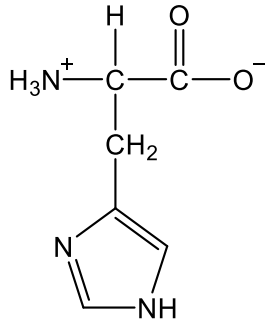
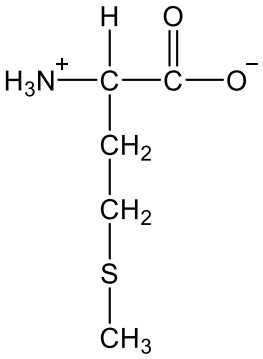
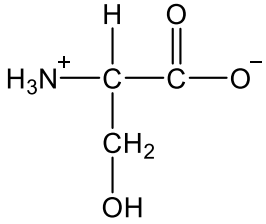
Question 42 (5 points)
Draw the H_3N^+-Cys-Cys-Pro-COO^- tripeptide (with a disulfide bridge/bond) at physiological pH.







Question 43 (15 points)
Draw the primary structure of the amino acid (indicated by its abbreviation) at physiological pH.

		
His	M	Ser

Bonus Question (5 points)
Phosphate is often abbreviated as P_i. What does the "i" mean?

inorganic

Potentially Useful Information

Equations

$$\Delta H_{reaction} = \sum \Delta H_{products} - \sum \Delta H_{reactants}$$

$$\Delta S_{universe} = \Delta S_{system} + \Delta S_{surroundings}$$

$$\Delta G = \Delta H - T\Delta S_{system}$$

$K_{eq} = \frac{[\mathrm{C}]^{\mathrm{c}}[\mathrm{D}]^{\mathrm{d}}}{[\mathrm{A}]^{\mathrm{a}}[\mathrm{B}]^{\mathrm{b}}}$ for the reaction: $\mathrm{aA} + \mathrm{bB} \rightleftharpoons \mathrm{cC} + \mathrm{dD}$

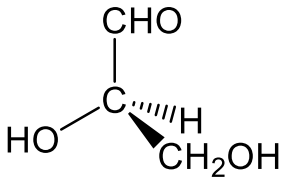
$$\Delta G = \Delta G° + RT \ln \frac{[\mathrm{C}]^{\mathrm{c}}[\mathrm{D}]^{\mathrm{d}}}{[\mathrm{A}]^{\mathrm{a}}[\mathrm{B}]^{\mathrm{b}}}$$

$$\Delta G° = -RT \ln K_{eq}$$

$$\Delta G°' = \Delta G° + RT \ln[\mathrm{H}^+]$$

Constants

Gas Constant, R	0.08206 L·atm·K^{-1}·mol^{-1} 0.08314 L·bar·K^{-1}·mol^{-1} 8.314 J mol^{-1} K^{-1}



D-Glyceraldehyde

Acid Dissociation Constants for the 20 Standard Amino Acids

Amino Acid	$pK_a(COOH)$	$pK_a(NH_3^+)$	$pK_a(R)$
Alanine	2.33	9.71	
Arginine	2.03	9.00	12.10
Asparagine	2.16	8.73	
Aspartic Acid	1.95	9.66	3.71
Cysteine	1.91	10.28	8.14
Glutamine	2.18	9.00	
Glutamic Acid	2.16	9.58	4.15
Glycine	2.34	9.58	
Histidine	1.70	9.09	6.04
Isoleucine	2.26	9.60	
Leucine	2.32	9.58	
Lysine	2.15	9.16	10.67
Methionine	2.16	9.08	
Phenylalanine	2.18	9.09	
Proline	1.95	10.47	
Serine	2.13	9.05	
Threonine	2.20	8.96	
Tryptophan	2.38	9.34	
Tyrosine	2.24	9.04	10.10
Valine	2.27	9.52	