

Student name: _____

Student number: _____

92 possible points

hydrogen 1 H 1.0079																	helium 2 He 4.0026		
lithium 3 Li 6.941	beryllium 4 Be 9.0122											boron 5 B 10.811	carbon 6 C 12.011	nitrogen 7 N 14.007	oxygen 8 O 15.999	fluorine 9 F 18.998	neon 10 Ne 20.180		
sodium 11 Na 22.990	magnesium 12 Mg 24.305											aluminum 13 Al 26.982	silicon 14 Si 28.086	phosphorus 15 P 30.974	sulfur 16 S 32.065	chlorine 17 Cl 35.453	argon 18 Ar 39.948		
		scandium 21 Sc 44.956	titanium 22 Ti 47.867	vanadium 23 V 50.942	chromium 24 Cr 51.996	manganese 25 Mn 54.938	iron 26 Fe 55.845	cobalt 27 Co 58.933	nickel 28 Ni 58.693	copper 29 Cu 63.546	zinc 30 Zn 65.39	gallium 31 Ga 69.723	germanium 32 Ge 72.61	arsenic 33 As 74.922	selecnium 34 Se 78.96	bronine 35 Br 79.904	krypton 36 Kr 83.80		
		yttrium 39 Y 88.906	zirconium 40 Zr 91.224	niobium 41 Nb 92.906	niobium 42 Mo 95.94	technetium 43 Tc [98]	ruthenium 44 Ru 101.07	rhodium 45 Rh 102.91	palladium 46 Pd 106.42	silver 47 Ag 107.87	cadmium 48 Cd 112.41	indium 49 In 114.82	tin 50 Sn 118.71	antimony 51 Sb 121.76	tellurium 52 Te 127.60	iodine 53 I 126.90	xenon 54 Xe 131.29		
		cesium 55 Cs 132.91	barium 56 Ba 137.33	* 57-70 Lu 174.97	hafnium 72 Hf 178.49	tantalum 73 Ta 180.95	tungsten 74 W 183.84	rhenium 75 Re 186.21	osmium 76 Os 190.23	iridium 77 Ir 192.22	platinum 78 Pt 195.08	gold 79 Au 196.97	mercury 80 Hg 200.59	thallium 81 Tl 204.38	lead 82 Pb 207.2	bismuth 83 Bi 208.98	polonium 84 Po [209]	astatine 85 At [210]	radon 86 Rn [222]
		francium 87 Fr [223]	radium 88 Ra [226]	** 89-102 Lr [262]	rutherfordium 104 Rf [261]	dubnium 105 Db [262]	seaborgium 106 Sg [263]	bohrium 107 Bh [264]	hassium 108 Hs [269]	meitnerium 109 Mt [268]	unnilium 110 Uun [271]	ununium 111 Uuu [272]	unbinium 112 Uub [273]	ununquadium 114 Uuq [289]					

* Lanthanide series

lanthanum 57 La 138.91	cerium 58 Ce 140.12	praseodymium 59 Pr 140.91	neodymium 60 Nd 144.24	promethium 61 Pm [145]	samarium 62 Sm 150.36	europium 63 Eu 151.96	gadolinium 64 Gd 157.25	terbium 65 Tb 158.93	dysprosium 66 Dy 162.50	holmium 67 Ho 164.93	erbium 68 Er 167.26	thulium 69 Tm 168.93	ytterbium 70 Yb 173.04
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** Actinide series

actinium 89 Ac [227]	thorium 90 Th 232.04	protactinium 91 Pa 231.04	uranium 92 U 238.03	neptunium 93 Np [237]	plutonium 94 Pu [244]	americium 95 Am [243]	curium 96 Cm [247]	berkelium 97 Bk [247]	californium 98 Cf [251]	einsteinium 99 Es [252]	fermium 100 Fm [257]	mendeleevium 101 Md [258]	nobelium 102 No [259]
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True/False questions (total points: 15)

1.) The Urey-Miller experiment provided evidence that complex organisms evolved from simple organic molecules that were transported to primordial earth by meteorites.

True

① False. If false, why?

② The Urey-Miller experiment, which was done by applying an electrical charge to a number of primordial gases (CO₂, methane, H₂O, SO₂) in a round-bottom flask, produced a number of simple organic molecules. → reducing environment

2.) The endosymbiosis theory suggests that eukaryotic organism originated from symbiotic partnerships involving multiple prokaryotic organisms.

True

③

False. If false, why?

3.) All 20 canonical amino acids have the stereo-chemical S- configuration

True

① False. If false, why?

① glycine - no R/S stereo-chemistry
① Cysteine - R stereochemical configuration

4.) Water can act as both a proton acceptor and a proton donor. Therefore, it is an amphiphilic molecule.

True

① False. If false, why?

② amphiphilic molecules have hydrophobic & hydrophilic regions.

5.) The Henderson-Hasselbalch equation represents the titration curve of all weak acids.

True

③

False. If false, why?

Multiple choice questions (total points: 56, removed q. 14 and 15)

- 4 6.) A reaction can be considered spontaneous (favourable) if which of the following conditions are met:
- ΔH is negative and ΔS is negative at constant temperature
 - ΔH is positive and ΔS is positive below $\Delta T = \Delta H/\Delta S$
 - ΔH is negative and ΔS is positive
 - ΔH is positive and ΔS is negative above $\Delta T = \Delta H/\Delta S$
- 4 7.) The strongest, non-covalent chemical bond or force is:
- Hydrogen bonds
 - London Dispersion Forces
 - Van der Waals forces
 - Hydrophobic interactions
 - Electrostatic forces
- 4 8.) What type of chemical bond or force occurs between two non-polar amino acid side chains:
- London dispersion forces
 - Hydrophobic interaction
 - Hydrogen bonding
 - Electrostatic bonding
 - No chemical bonding occurs
- 4 9.) Solvation of the amino acid Y involves which of the following chemical bonds:
- Hydrogen bonding
 - Electrostatic bonding
 - London dispersion forces
 - Dipole-ion interactions
- 4 10.) What is the approximate side chain pK_a of lysine?
- 10.5
 - 4.07
 - 12.48
 - 7.06
- 4 11.) What is the approximate side chain pK_a of Asp?
- 6.85
 - 12.48
 - 10.54
 - 3.70
- 4 12.) The three-letter code and one-letter code for Asparagine is
- Asp & A
 - Asn & A
 - Asn & N
 - Asp & N

- 4 13.) The isoelectric point of a molecule is defined as:
- The pH at which the molecule carries no net charge
 - The pK_a at which the molecule carries no net charge
 - The pH at which the molecule carries only a positive charge
 - The pH at which the molecule carries only a negative charge

14.) At pH 2, the overall charge on the tripeptide Ala-Phe-Asp will be:

- +3
- +2
- +1
- 0
- 1
- 2
- 3

15.) At pH 10, the overall charge on the tetrapeptide Arg-Val-Glu-Lys will be:

- +3
- +2
- +1
- 0
- 1
- 2
- 3

9.14 < 9.15
removed

4 16.) At pH 7, the overall charge on the dipeptide EH will be:

- +3
- +2
- +1
- 0
- 1
- 2
- 3

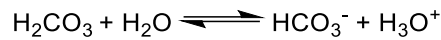
4 17.) The pK_a of phosphoric acid is 2.15. The K_a of phosphoric acid is:

- 5.37×10^{-8}
- 1.41×10^2
- 7.08×10^{-3}
- 7.08×10^{-1}

4 18.) The pH of an aqueous solution at 37°C is approximately 4.05. If succinic acid ($pK_a = 4.21$) is added to the solution, what will be the approximate ratio of conjugate base to acid?

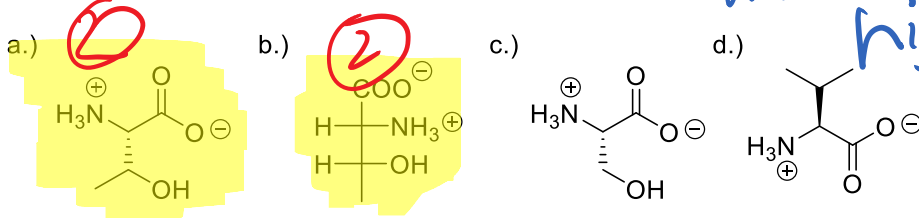
- 0.23/1
- 1.34/1
- 1.44/1
- 0.69/1

19.) What is the K_{eq} for the following reaction:



- 4
- a. = $[\text{H}_2\text{CO}_3] [\text{H}_2\text{O}] / [\text{HCO}_3^-] [\text{H}_3\text{O}^+]$
 - b. = $[\text{HCO}_3^-] [\text{H}_3\text{O}^+] / [\text{H}_2\text{CO}_3] [\text{H}_2\text{O}]$
 - c. = $[\text{HCO}_3^-] [\text{H}_2\text{O}] / [\text{H}_2\text{CO}_3] [\text{H}_3\text{O}^+]$
 - d. = $[\text{H}_2\text{CO}_3] [\text{H}_3\text{O}^+] / [\text{HCO}_3^-] [\text{H}_2\text{O}]$

20.) Circle the correct chemical structure for threonine:



21.) The RNA world hypothesis suggests which of the following:

- 4
- a. That the two amino acids, Gly & N, were formed chemically in a primordial soup.
 - b. RNA is thought to have evolved from DNA.
 - c. DNA and proteins evolved from self-replicating RNA systems.
 - d. life was thought to evolve over 6 billion years.

Long answer questions (total points: 21)

⑦ 22.) Given a solution containing 0.042 M monosodium phosphate (NaH_2PO_4) and 0.058 M disodium phosphate (Na_2HPO_4):

a. What is the pH of the solution, given the K_{a2} of H_2PO_4^- is 6.8×10^{-8} ?

$$\textcircled{1} \text{pH} = \text{p}K_a + \log \frac{[\text{HPO}_4^{2-}]}{[\text{H}_2\text{PO}_4^-]}$$

$$\text{pH} = 7.16 + \log \left(\frac{0.058}{0.042} \right)$$

$$\text{p}K_{a2} = -\log [6.8 \times 10^{-8}]$$

$$\textcircled{1} \text{p}K_{a2} = 7.16$$

$$\textcircled{1} \text{pH} = 7.30$$

b. If 1.0 mL of 10.0 M NaOH is added to a liter of the buffer prepared in part a, how much will the pH change?

$$\textcircled{1} 10.0 \text{ M NaOH} \times 0.001 \text{ L} = 0.01 \text{ Mol NaOH}$$

Moles NaOH will titrate an equivalent amount of HA to A^- , therefore:

$$\textcircled{1} \text{A}^- : 0.058 + 0.01 = 0.068$$

$$\textcircled{1} \text{HA} : 0.042 - 0.01 = 0.032$$

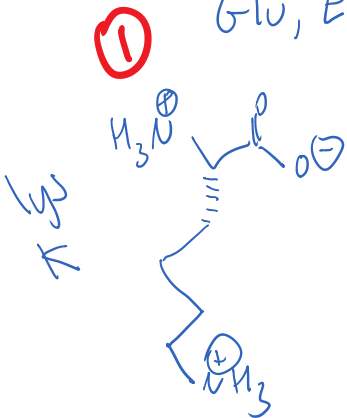
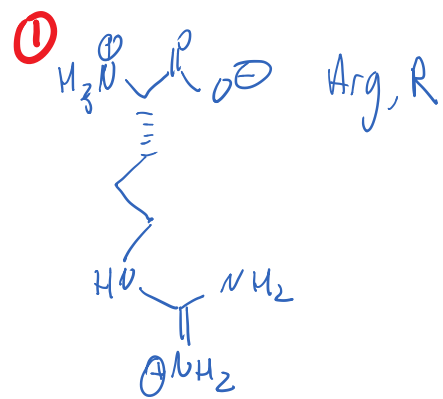
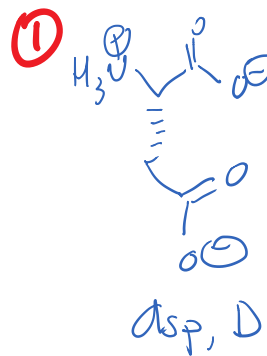
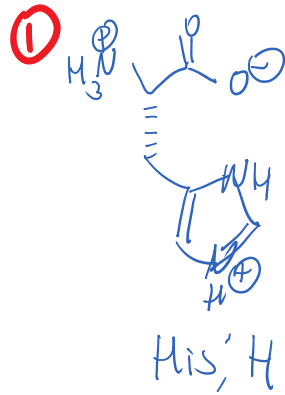
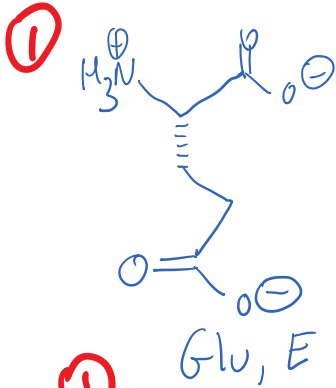
$$\text{pH} = 7.16 + \log \left(\frac{0.068}{0.032} \right)$$

$$\textcircled{1} \text{pH} = 7.49$$

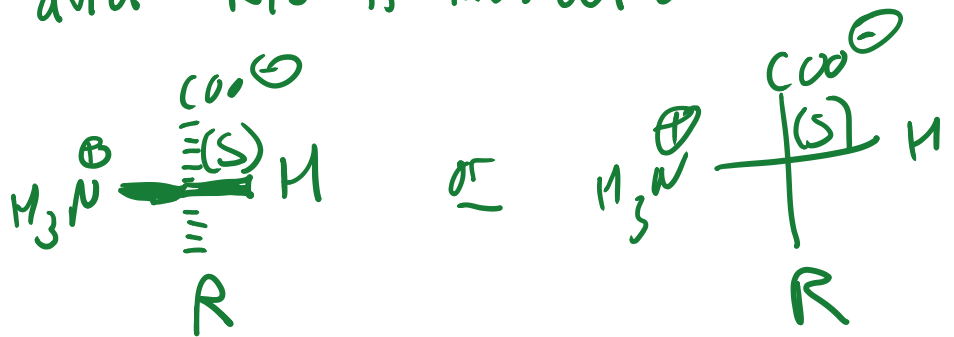
23.) Draw the chemical structure, including proper stereochemistry, for the 5 polar, charged amino acids. Assume that these amino acids are found in a solution of aqueous media (pH ~ 7). Be sure to circle the final amino acid structures.

① = proper stereochem ① = charged NH_3^+ & $-\text{COO}^-$

7



• May have students who indicate or draw D/L: That is okay, as long as it is drawn properly and R/S is indicated



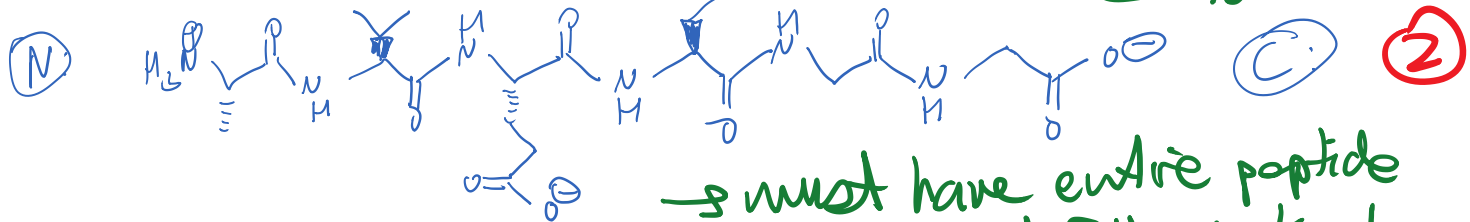
24.) A biochemist has identified two hexapeptides that intermolecularly interact at neutral pH:

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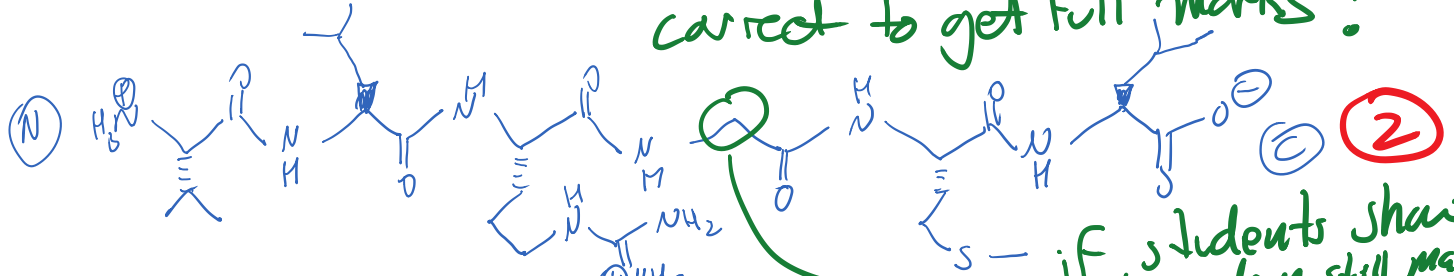
AVEKGG
VLRGML

a. Draw the structure of both hexapeptides. Be sure to include proper stereochemistry and label the N & C terminus of each polypeptide.

Some students may have drawn like this is correct.



→ must have entire peptide correct to get full marks!



if students show stereochem, still mark correct.

b. Two residues on each of the hexapeptide form strong, non-covalent intermolecular interactions. Identify (using the three-letter code for the given amino acid) the two residues on each of the hexapeptide and indicate the type of non-covalent bonding that can occur.

peptide ①: Glu ①, Arg : Hydrogen bond + electrostatic, dipole-charge
 peptide ②: Arg : Hydrogen + electrostatic ①