Chemistry 2713 Name: ________________________

Biochemistry Student Number: _______________

Winter 2018

Final Exam

Answer all questions on the exam. Each multiple choice question has a value of two points and must be answered on the test by circling the best answer. The value for each short answer question is given with the questions.

Programmable calculators are not allowed.

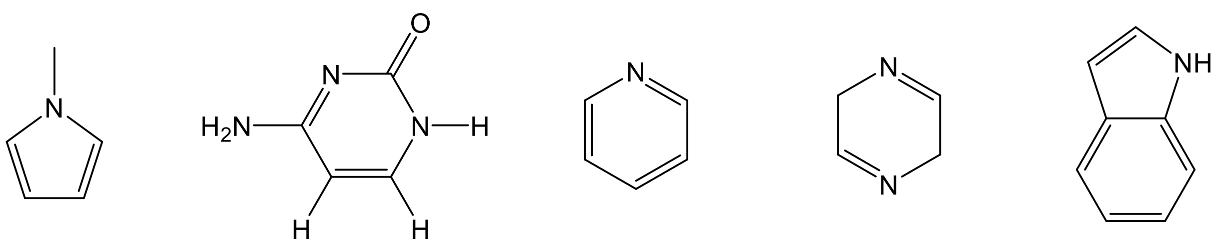
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1 H 1.008																	2 He 4.003
3 Li 6.941	4 Be 9.012											5 B 10.81	6 C 12.01	7 N 14.01	8 O 16.00	9 F 19.00	10 Ne 20.18
11 Na 22.99	12 Mg 24.30											13 Al 26.98	14 Si 28.09	15 P 30.97	16 S 32.06	17 Cl 35.45	18 Ar 39.95
19 K 39.10	20 Ca 40.08	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		/200
Structure Drawing		/115
Bonus		/15
Total		/315

Question 1
Phosphate is often abbreviated as P_i in biochemistry. What does the "i" mean?

a. inorganic
b. ion
c. ionic
d. ionized
e. isoelectric

Question 2
Which of the following molecules is *not* aromatic?



A B C D E

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

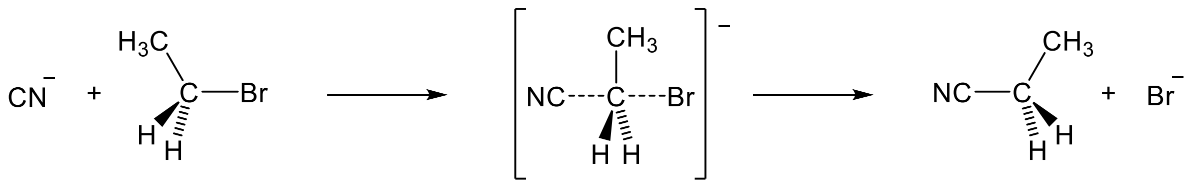
Question 3
Peptide bonds are formed through condensation reactions between:

a. ketones and amines
b. carboxylic acids and amines
c. carboxylic acids and amides
d. ketones and amides
e. amines and amides

Question 4
Macromolecular biological catalysts are called _____.

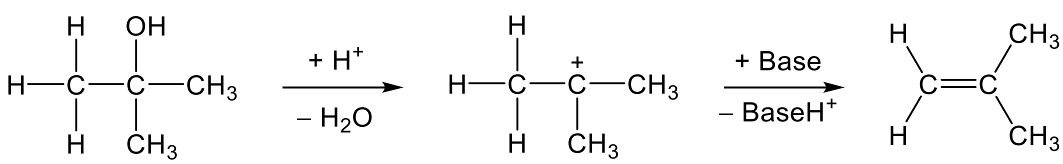
a. clathrates
b. micelles
c. enzymes
d. carbohydrates
e. polymers

Question 5
What type of mechanism is shown by the following reaction scheme:



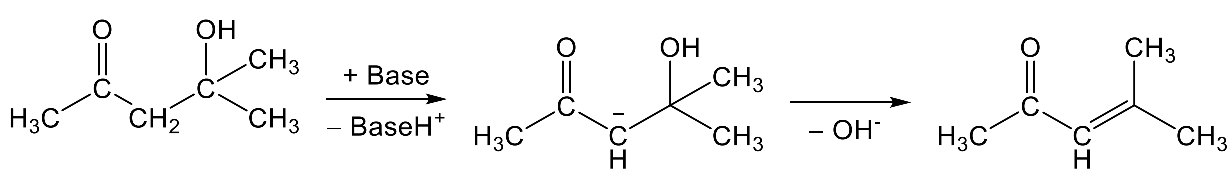
a. S_N1
b. S_N2
c. E1
d. E1cb
e. E2

Question 6
What type of mechanism is shown by the following reaction scheme:



a. S_N1
b. S_N2
c. E1
d. E1cb
e. E2

Question 7
What type of mechanism is shown by the following reaction scheme:



a. S_N1
b. S_N2
c. E1
d. E1cb
e. E2

Question 8
Molecules that are repelled by water (water-hating) are called:

a. aquaphoblic
b. hydrophobic
c. hydrophilic
d. amphipathic
e. ambiphilic

Question 9
What forms when small amounts of fatty acids salts are added to water?

a. macromolecules
b. clathrates
c. micelles
d. osmosis
e. zeolytes

Question 10
Which of the following is one of the important buffers in our bodies?

a. acetate buffer
b. bicarbonate buffer
c. carbohydrate buffer
d. carbonate buffer
e. phospholipid buffer

Question 11
When cells are in a solution with lower solute concentration than in the cells, this is known as a(n) _____ solution.

a. hypertonic
b. hypotonic
c. isotonic
d. subtonic
e. supratonic

Question 12
When blood pH falls below 7.35, a condition called _____ occurs.

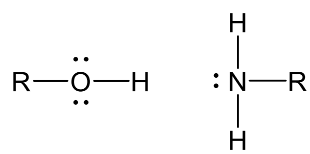
a. acidosis
b. acidphilic
c. alkaphilic
d. alkalosis
e. acidalkosis

Question 13
Rank the following types of non-covalent bonding from strongest to weakest:

Dipole-Dipole   Dipole-Induced Dipole   Hydrogen Bonds   Induced Dipole-Induced Dipole

a. Dipole-Dipole > Dipole-Induced Dipole > Induced Dipole-Induced Dipole > Hydrogen Bonds
b. Induced Dipole-Induced Dipole > Dipole-Induced Dipole > Dipole-Dipole > Hydrogen Bonds
c. Hydrogen Bonds > Dipole-Dipole > Dipole-Induced Dipole > Induced Dipole-Induced Dipole
d. Hydrogen Bonds > Induced Dipole-Induced Dipole > Dipole-Induced Dipole > Dipole-Dipole
e. Dipole-Dipole > Dipole-Induced Dipole > Hydrogen Bonds > Induced Dipole-Induced Dipole

Question 14
What type of non-covalent bonding is primarily responsible for the interaction shown below?



a. dipole-induced dipole
b. hydrogen bonding
c. ion-dipole
d. ion-ion
e. van der Waals

Question 15
Which acid-base pair would make the best buffer?

a. $NaOH$ + $Na[HCO_2]$
b. HCl + HCO_2H
c. NH_3 + $Na[HCO_2]$
d. HCO_2H + $Na[HCO_2]$
e. HCl + $NaOH$

Question 16
Which weak acid/conjugate base pair would be the best choice for a buffer with a pH of 4.0?

a. acetic acid / acetate
b. benzoic acid / benzoate
c. formic acid / formate
d. lactic acid / lactate
e. propanoic acid / propanoate

Question 17
A semipermeable membrane separates two aqueous solutions X and Y at 20 °C.
Determine the net flow of water (if any). Assume 100% dissociation for salts.
Solution X: 0.1 M $Al(NO_3)_3$ Solution Y: 0.2 M KNO_3

a. towards X
b. towards Y
c. pressure builds on both sides
d. no net flow
e. overall drop in pressure

Question 18
Which of the following is not a standard condition for standard free energy?

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

Question 19
In order for two reactions to be coupled what conditions must be met?

a. They must both be spontaneous
b. One of the reactions must be spontaneous
c. A product of one of the reactions must be a reactant in the second reaction
d. Neither of the reactions must be spontaneous
e. Both B and C must be true

Question 20
For a reaction to be spontaneous which of the following statements must be *true*?

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

Question 21
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. in an open system 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 22
Which of the following processes are *not* driven by the hydrolysis of ATP?

a. active transport of substances across membranes
b. biosynthesis of biomolecules
c. hydrolysis of ADP to AMP
d. mechanical work such as muscle contraction
e. none, they are all driven by ATP hydrolysis

Question 23
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 24
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. A, B and C are correct
e. B and C are correct

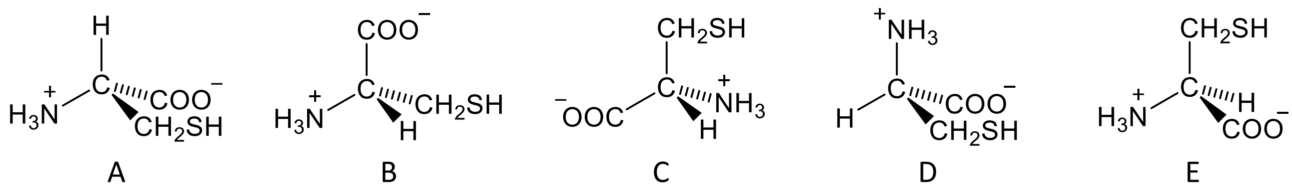
Question 25
An organism at equilibrium is said to be _____.

a. at rest
b. dissipative
c. organized
d. dead
e. formant

Question 26
Which of the following amino acids is *not* chiral?

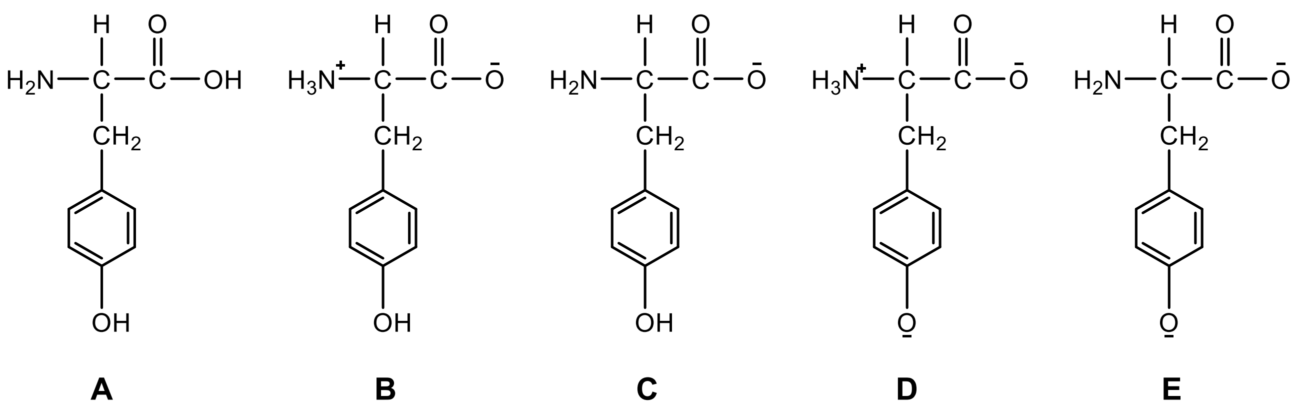
a. alanine
b. glycine
c. leucine
d. proline
e. valine

Question 27
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 28
What is the principal form of tyrosine at pH 9.0?

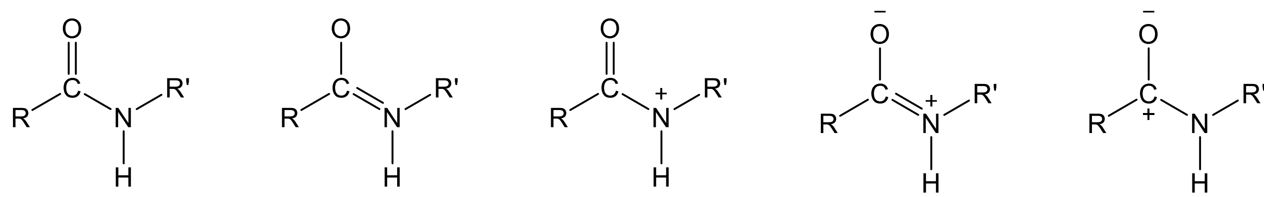


a. A
b. B
c. C
d. D
e. E

Question 29
Which of the following is not a class of amino acid?

a. acidic
b. asymmetric
c. basic
d. nonpolar
e. polar

Question 30
Which structure best represents the actual structure of a peptide bond?



A B C D E

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

Question 31
What is the isoelectric point of alanine?

a. 2.33
b. 6.02
c. 6.83
d. 9.71
e. 12.04

Question 32
When not at the terminal of a protein, which of the following cannot contribute to the pI of a protein?

a. aspartate
b. cysteine
c. leucine
d. lysine
e. tyrosine

Question 33
What is the isoelectric point of lysine?

a. 5.66
b. 6.41
c. 7.01
d. 8.52
e. 9.92

Question 34
Which of the following amino acids would be classified as a nonstandard amino acid?

a. tyrosine
b. lysine
c. cystine
d. glycine
e. arginine

Question 35
The 21st proteinogenic amino acid is:

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

Question 36
The three-letter abbreviation for arginine is:

a. Ala
b. Apg
c. Arg
d. Asn
e. Asp

Question 37
The one-letter abbreviation for tyrosine is:

a. A
b. F
c. H
d. T
e. Y

Question 38
The amino acid sequence of a polypeptide is referred to as its ________structure.

a. peptide
b. primary
c. quaternary
d. secondary
e. tertiary

Question 39
The overall three-dimensional structure of a polypeptide is referred to its _____ structure.

a. primary
b. secondary
c. tertiary
d. macroscopic
e. microscopic

Question 40
α-helices are associated with what level of protein structure?

a. primary
b. secondary
c. tertiary
d. macroscopic
e. microscopic

Question 41
Invariant amino acids in a protein are presumed:

a. to be unimportant in the structure and function of the protein
b. to be essential to the structure and function of the protein
c. always to occur at the beginning of the amino acid sequence of an enzyme
d. always to occur at the end of the amino acid sequence of an enzyme
e. to be part of the prosthetic group

Question 42
A prosthetic group is a:

a. repair enzyme
b. group other than an amino acid that is part of a protein
c. group that generates the native form of a protein
d. disulfide bridge
e. group that reduces enzyme activity

Question 43
Which of the following amino acids would foster an α-helix?

a. alanine
b. aspartate
c. glycine
d. proline
e. tryptophan

Question 44
Which of the following amino acids would be found in a β-turn?

a. alanine
b. leucine
c. lysine
d. proline
e. tyrosine

Question 45
Which pair of amino acids can form salt bridges between their side chains at physiological pH?

a. serine and glutamine
b. tryptophan and phenylalanine
c. lysine and histidine
d. aspartate and arginine
e. none of the above

Question 46
If a polypeptide has a low pI value, which of the following amino acids is likely to be present?

a. lysine
b. serine
c. valine
d. aspartate
e. arginine

Question 47
Which of the following interactions do not stabilize tertiary structure?

a. hydrophobic interactions
b. electrostatic interactions
c. hydrogen bonds
d. covalent bonds
e. none of the above

Question 48
Detergents denature proteins by disrupting which of the following?

a. hydrogen bonds
b. disulfide bridges
c. hydrophobic interactions
d. salt bridges
e. both A and D are correct

Question 49
Which of the following is not a common denaturing condition in biological systems?

a. high temperature
b. heavy metal ions
c. mechanical stress
d. organic solvents
e. strong acids

Question 50
What type of process is the denaturation of egg albumin by heating?

a. equilibrium
b. exothermic
c. irreversible
d. osmotic
e. reversible

Question 51
Why is a peptide bond stronger than an ester bond?

a. greater electronegativity of nitrogen
b. greater electronegativity of oxygen
c. resonance stabilization of the amide bond
d. increased basicity of nitrogen
e. size of the nitrogen atom compared to the oxygen atom

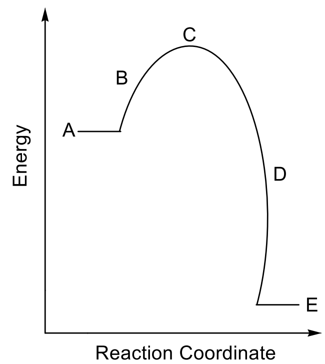
Question 52
In gel-filtration chromatography:

a. proteins are separated by charge
b. non-polar proteins elute first
c. separation is based on a highly specific interaction with the stationary phase
d. large proteins elute first
e. small proteins elute first

Question 53
Enzymes act by?

a. counteracting inhibitors
b. decreasing the energy of activation of a reaction
c. increasing the number of molecular collisions
d. raising the temperature of a reaction
e. shifting the equilibrium constant towards the products

Question 54
Consider the following diagram. What constitutes the activation energy for the forward reaction?



a. A – C
b. A – E
c. C – A
d. C – E
e. E – A

Question 55
In contrast to inorganic catalysts, enzymes have an intricately shaped surface called the _______.

a. substrate
b. cofactor
c. active site
d. apoenzyme
e. holoenzyme

Question 56
Enzyme studies are best carried out:

a. in dilute aqueous solution
b. in highly concentrated solutions of the enzyme
c. in highly concentrated solutions of the substrate
d. in the presence of an inert crowding agent
e. in the presence of a membrane

Question 57
The lock and key model of enzyme activity proposes that each:

a. enzyme can react with only a single substrate
b. enzyme has a cofactor that promotes the catalytic activity
c. substrate has a specific cofactor that binds it to the enzyme
d. enzyme binds a specific substrate because the active site and substrate have complementary structures
e. both A and B are correct

Question 58
Which of the following statements regarding cooperative binding is true?

a. two or more proteins aid the binding of a ligand
b. the binding of one ligand aids the binding of a second ligand
c. the folding of part of a protein aids in the folding of the remainder of the protein
d. all proteins engage in cooperative binding
e. the binding of a cofactor to a protein aids in the binding of a ligand

Question 59
Alcohol dehydrogenase without NAD^+ is called a(n) _____:

a. apoenzyme
b. holoenzyme
c. hyperenzyme
d. hypoenzyme
e. subenzyme

Question 60
Zn^{2+}, as part of alcohol dehydrogenase, is a:

a. cocatalyst
b. coenzyme
c. cofactor
d. covalent
e. covitamin

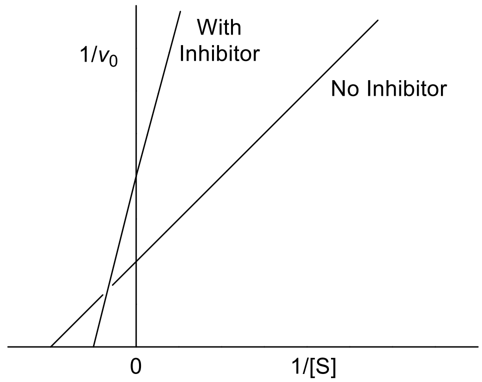
Question 61
Which of the following is not a property of enzymes?

a. always requires a co-enzyme to function properly
b. capable of being regulated
c. highly specific
d. reaction rates high in comparison to the uncatalyzed reaction
e. side products of reactions are rare

Question 62
Which of the following amino acids cannot actively participate in a catalytic site?

a. serine
b. threonine
c. tyrosine
d. glycine
e. glutamine

Question 63
Consider the Lineweaver-Burk plot below. Identify the type of inhibitory action shown.



a. competitive inhibition
b. pure noncompetitive inhibition
c. mixed noncompetitive inhibition
d. uncompetitive inhibition
e. irreversible inhibition

Question 64
The term synthetase is included in which class of enzymes?

a. hydrolase
b. isomerase
c. lyase
d. ligase
e. transferase

Question 65
Enzyme control is accomplished in which of the following ways?

a. genetic control
b. covalent modification
c. allosteric regulation
d. compartmentation
e. all of the above are correct

Question 66
The kinetics for hydrolysis reactions in biological systems are assumed to follow:

a. zero-order reactions
b. first-order reactions
c. second-order reactions
d. pseudo-first-order reactions
e. pseudo-second-order reactions

Question 67
Which of the following amino acids is capable of acting as a general acid or general base at physiological pH?

a. glycine
b. histidine
c. tyrosine
d. tryptophan
e. proline

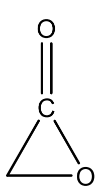
Question 68
Which of the following is *not* a feature of d-block metals that makes them efficient cofactors?

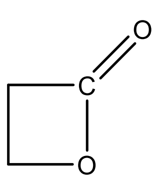
a. can act as a Lewis acid
b. can exist as a variety of oxidation states
c. Have a maximum positive charge of +2
d. have directed orbitals
e. readily form four to six bonds

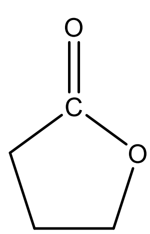
Question 69
What type of enzyme catalyzes the following reaction?

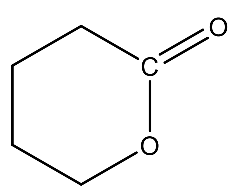
a. isomerase
b. ligase
c. lyase
d. oxidoreductase
e. transferase

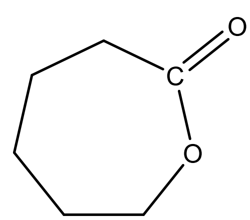
Question 70
Which of the following is a γ-lactone?


A


B

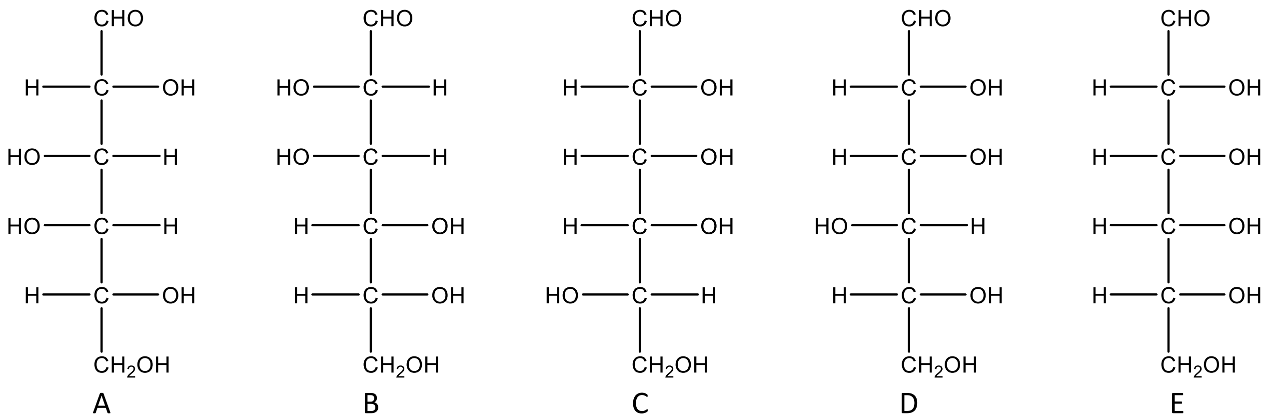

C


D


E

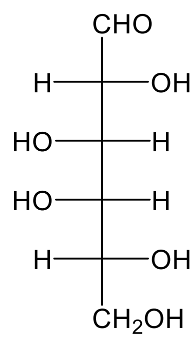
a. A
b. B
c. C
d. D
e. E

Question 71
Which of the following carbohydrates does not belong to the family of naturally occurring sugars?



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

Question 72
Which sugar is represented by the following Fisher projection?

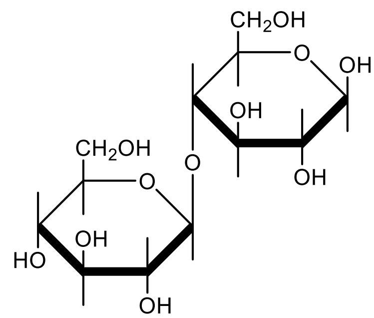


a. altrose
b. galactose
c. glucose
d. idose
e. mannose

Question 73
What is the three-letter abbreviation for glucose?

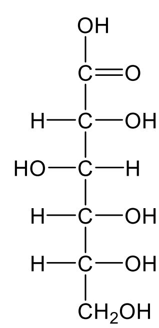
a. Glc
b. Glu
c. Gos
d. Guc
e. Gul

Question 74
What type of linkage is connecting the following disaccharide?



a. α(1,1)
b. β(1,1)
c. α(1,4)
d. β(1,4)
e. αβ(1,1)

Question 75
The following oxidized monosaccharide is an example of an _________.



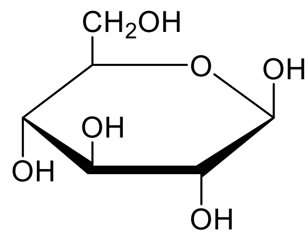
a. aldaric acid
b. aldonic acid
c. ironic acid
d. uronic acid
e. urdaric acid

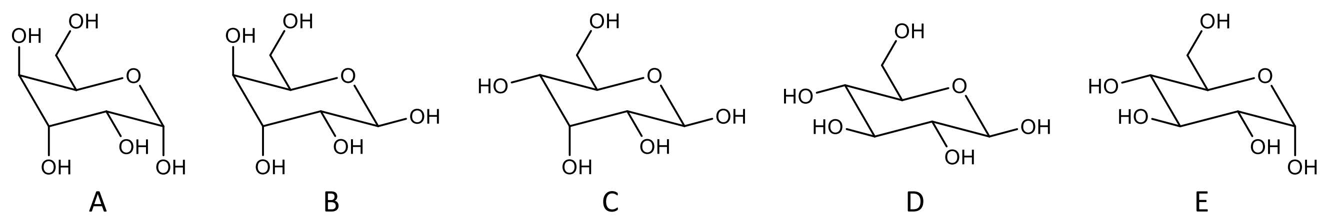
Question 76
Which of the following carbohydrates is a nonreducing sugar?

a. glucose
b. fructose
c. lactose
d. sucrose
e. ribose

Question 77

Which of the following chair conformations is represented by the Haworth projection shown below?





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

Question 78

A glycosidic link is chemically a(n) _____.

a. ether
b. ester
c. amide
d. aldehyde
e. ketone

Question 79

Cellulose is indigestible to most animals because:

a. cellulose is not soluble in water
b. animals lack the enzymes required to hydrolyse the β-links of the cellulose
c. cellulose has no food value and therefore cannot be digested
d. cellulose has chemical bonds that cannot be broken
e. none of the above are correct

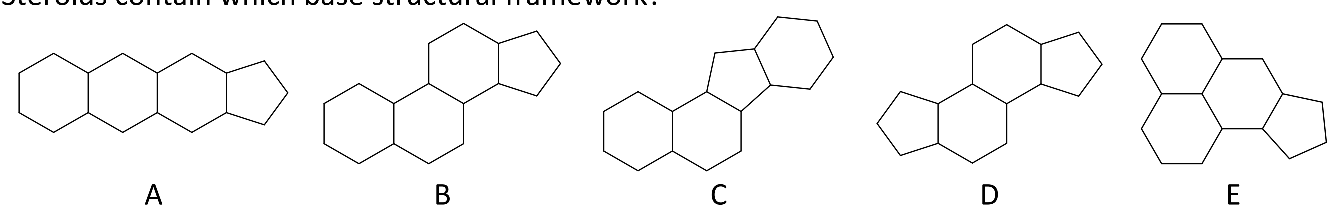
Question 80
Lactose intolerance arises from:

a. bacteria in the intestine that produce toxic metabolites
b. the inability of intestinal enzymes to cleave lactose
c. a sensitivity to galactose
d. a sensitivity to glucose
e. an allergic reaction to glucose

Question 81
The three most common homoglycans found in nature are cellulose, starch and _____.

a. amylose
b. lactose
c. fructose
d. glycogen
e. sucrose

Question 82
Steroids contain which base structural framework?



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

Question 83
ω-6 Fatty acids:

a. have a double bond six carbon atoms from the carbonyl end of the chain
b. have a double bond six carbon atoms from the methyl end of the chain
c. have six double bonds in the molecule
d. have three more double bonds than ω-3 fatty acids
e. contain six *trans* double bonds in the molecule

Question 84
Which of the following is not likely to be a naturally occurring fatty acid?

a. $C_{13}H_{27}COOH$
b. $C_{14}H_{29}COOH$
c. $C_{15}H_{31}COOH$
d. $C_{17}H_{35}COOH$
e. $C_{19}H_{39}COOH$

Question 85
How many isoprene units does a sesquiterpene contain?

a. 1
b. 2
c. 3
d. 4
e. 5

Question 86
The double bonds in naturally occurring fatty acids are usually _____ isomers.

a. *cis*
b. *trans*
c. mixture of *cis* and *trans*
d. essential
e. nonessential

Question 87
Glycerols are formed through condensation reactions between:

a. ketones and alcohols
b. carboxylic acids and alcohols
c. carboxylic acids and ethers
d. ketones and amides
e. carboxylic acids and amides

Question 88
What is the primary role of sodium citrate in Benedict's reagent (used in lab, Experiment 6: Dialysis and Carbohydrates), which is used to test for reducing sugars?

a. to act as an indicator by changing colour (blue → red)
b. to bind the sulfate counterion so it does not interfere with the reaction
c. to keep the copper in solution
d. to make the solution basic
e. to precipitate the red copper product

Question 89

In lab (Experiment 4: Isolation and Characterization of Bacterial DNA) the DNA concentration in your sample was determined by the diphenylamine reaction. What is the role of diphenylamine in this reaction?

a. to deprotonate the nucleic acid
b. to depurinate the DNA
c. to form a condensation product with deoxyribose
d. to hydrolyze the β-N-glycosidic bond
e. to reduce the nucleic acid

Question 90

Bovine serum albumin (BSA) is a biochemically useful protein. A 0.416 g sample of bovine serum albumin is dissolved in water to make 0.181 L of solution, and the osmotic pressure of the solution at 25 °C is found to be 0.858 mbar. Calculate the molecular mass of bovine serum albumin.
Note: 1 atm = 1.01325 bar

a. 2,680 g mol^{-1}
b. 62,700 g mol^{-1}
c. 65,500 g mol^{-1}
d. 66,400 g mol^{-1}
e. 6,720,000 g mol^{-1}

Question 91

What is the pH of a 1.0 M monosodium ascorbate, $Na[C_6H_7O_6]$, solution?

a. 2.50
b. 5.00
c. 5.65
d. 8.15
e. 11.30

Question 92
What is the pH of 0.25 M lactic acid?

a. 0.60
b. 1.93
c. 2.24
d. 3.14
e. 3.86

Question 93
What is the pH of a solution prepared by adding 43.2 g of LiOH (molar mass = 24 g mol^{-1}) to 600 mL of a 3.0 M acetic acid solution?

a. 4.38
b. 9.25
c. 9.51
d. 9.62
e. 11.86

Question 94

If a 0.25 M buffer solution of acetic acid and sodium acetate has a pH of 4.45, what is the concentration of acetate?

a. 0.044 M
b. 0.082 M
c. 0.12 M
d. 0.17 M
e. 0.23 M

Question 95

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. −2902 kJ mol^{-1}
c. −4444 kJ mol^{-1}
d. −5645 kJ mol^{-1}
e. −8794 kJ mol^{-1}

Question 96

Rhenium-188 is used to beta irradiate coronary arteries from an angioplasty balloon. This radioactive isotope breaks down in a first-order process with a half-life of 17 h. How long before 75% of the radioactive rhenium has decayed?

a. 7.1 h
b. 17.0 h
c. 25.5 h
d. 34.0 h
e. 51.0 h

Question 97

Consider the following reaction in which the sugar ribose reacts with ATP to form ribose-5-phosphate:

$$\text{ATP} + \text{Ribose} \longrightarrow \text{ADP} + \text{Ribose-5-phosphate}$$

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

	$\Delta G°'$ (kJ mol^{-1})
ATP $\longrightarrow$ ADP + P_i	–30.5
Ribose + P_i $\longrightarrow$ Ribose-6-phosphate	+16.6

a. 1
b. 13.9
c. 273
d. 362
e. 812

Question 98

If $\Delta G°'$ 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. –42.4 kJ mol^{-1}
c. –43.6 kJ mol^{-1}
d. –47.4 kJ mol^{-1}
e. –52.8 kJ mol^{-1}

Question 99

Adults have an average saliva pH of 6.5. What is the average hydrogen ion concentration $[H^+]$ in your saliva?

a. 3.16×10^{-8} M
b. 3.16×10^{-7} M
c. 1.00×10^{-6} M
d. –0.813 M
e. the K_a of the acid is needed to calculate $[H^+]$

Question 100
What is the pH of a buffer containing 1.2 M ammonia and 1.4 M ammonium chloride?

a. 4.67
b. 4.81
c. 7.97
d. 9.19
e. 9.33

Question 101 (6 points)
Calculate the unknown riboflavin concentration from the absorbance data.

[Riboflavin] (M)	Absorbance
0.5×10^{-5}	0.0942
1.0×10^{-5}	0.188
2.0×10^{-5}	0.377
3.0×10^{-5}	0.566
4.0×10^{-5}	0.754
5.0×10^{-5}	0.942
unknown	0.439

Question 102 (9 points)
Calculate K_m from the following kinetic data.

[S] (mM)	v_0 ($mM \cdot s^{-1}$)
2	76.92
4	148.1
8	275.9
16	484.8
32	780.5

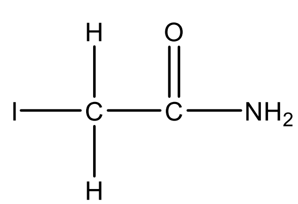
Question 103 (10 points)
Draw Lewis structures (including all resonance structures) of the following compounds:

PO_4^{3-}

Arg (at physiological pH)
only consider side-chain resonance

Question 104 (10 points)
Draw the E2 mechanism for the reaction of 1-bromopropane with methoxide.

Question 105 (10 points)
Iodoacetamide (shown below) is an irreversible inhibitor of several enzymes that have a cysteine residue in their active sites. Draw an appropriate mechanism for the reaction of iodoacetamide with cysteine at physiological pH.



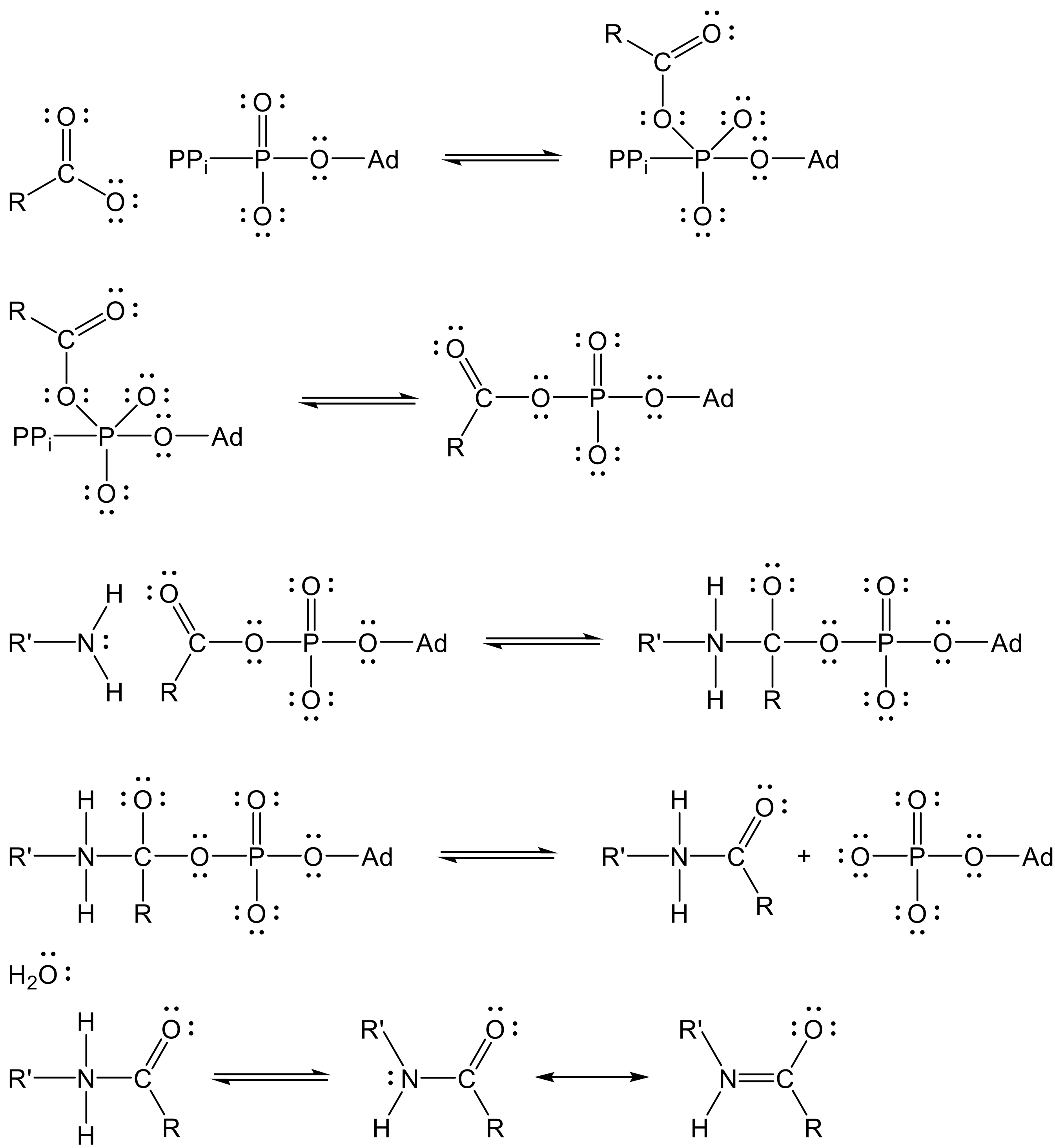
Question 106 (45 points)

Draw the structure at physiological pH of the amino acids with the following three-letter abbreviations.

His	Tyr	Sec
Trp	Leu	Pro
Asp	Phe	Met

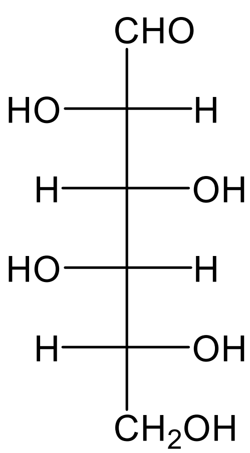
Question 107 (10 points)

The following scheme depicts the mechanism for peptide bond formation. Complete the mechanism by adding charges, small molecules and curved arrows.



Question 108 (5 points)
Draw any tripeptide that contains an intramolecular disulfide bridge.

Question 109 (5 points)
Draw the Haworth structure of the sugar (α isomer) depicted below as its Fischer projection.



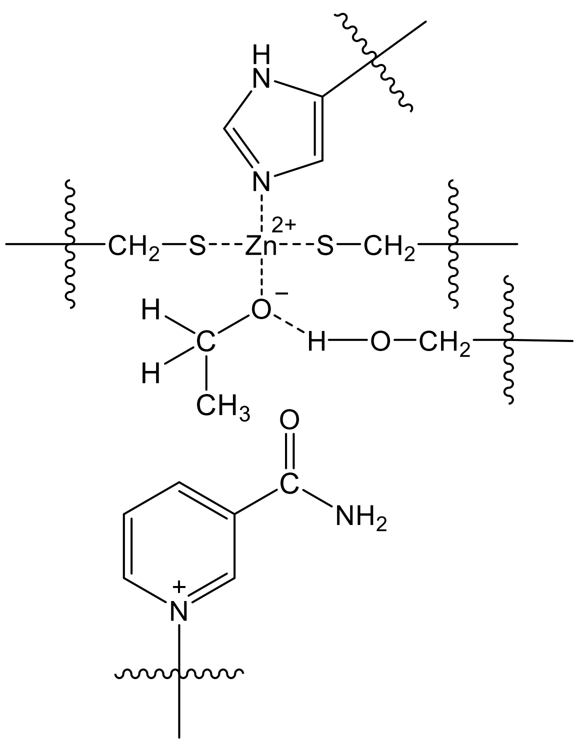
Question 110 (5 pts.)

Draw the naturally occurring fatty acid represented by the designation 18:2($\Delta^{9,12}$).

Bonus Question (15 points)

Complete the mechanism for alcohol dehydrogenase by adding curved arrows and draw the products. You do not need to add all non-bonding electrons, but adding some non-bonding electrons may help.

Note: the wavy lines denote that only part of a larger structure is shown.



Potentially Useful Information

Equations

pH = –log $[H^+]$	$K_w = [H^+][OH^-]$	Q = mCΔT
pOH = –log $[OH^-]$	$K_w = K_a \times K_b$	π= iMRT
pK_w = pH + pOH = 14	$pK_a = -\log K_a$	A = εlc
$pK_w = pK_a + pK_b = 14$	$pK_b = -\log K_b$	

$$K_a = \frac{[\mathrm{H}^+][\mathrm{A}^-]}{[\mathrm{HA}]} \qquad K_b = \frac{[\mathrm{HB}^+][\mathrm{OH}^-]}{[\mathrm{B}]} \qquad \mathrm{pH} = \mathrm{p}K_a + \log\frac{[\mathrm{base}]}{[\mathrm{acid}]}$$

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

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

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

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

$$\Delta G = \Delta G^\circ + RT\ln\frac{[\mathrm{C}]^{\mathrm{c}}[\mathrm{D}]^{\mathrm{d}}}{[\mathrm{A}]^{\mathrm{a}}[\mathrm{B}]^{\mathrm{b}}} \qquad \Delta G^\circ = -RT\ln K_{eq} \qquad \Delta G^{\circ\prime} = \Delta G^\circ + RT\ln[\mathrm{H}^+]$$

$\frac{k_F}{k_R} = \frac{[\mathrm{B}]^m}{[\mathrm{A}]^n} = K_{eq}$ for $k_F[\mathrm{A}]^n = k_R[\mathrm{B}]^m$

$$v_0 = \frac{-\Delta[\mathrm{S}]}{\Delta t} = \frac{\Delta[\mathrm{P}]}{\Delta t} \qquad v = \frac{\mathrm{V}_{max}[\mathrm{S}]}{[\mathrm{S}] + K_m} \qquad k_{cat} = \frac{\mathrm{V}_{max}}{[E_t]}$$

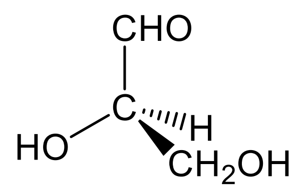
$$\frac{1}{v_0} = \frac{K_m}{\mathrm{V}_{max}}\frac{1}{[S]} + \frac{1}{\mathrm{V}_{max}}$$

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}
Specific Heat Capacity of Water, C	4.178 J g^{-1} $°C^{-1}$
Ion Product of Water at 25 °C, K_w	1.0×10^{-14}

Dissociation Constants and pK_a Values for Selected Monoprotic Weak Acids

Weak Acid	K_a	pK_a
Acetic Acid, CH_3COOH	1.76×10^{-5}	4.76
Benzoic Acid, C_6H_5COOH	6.31×10^{-5}	4.20
Butanoic Acid, $CH_3CH_2CH_2CH_2COOH$	1.54×10^{-5}	4.81
Formic Acid, $HCOOH$	1.78×10^{-4}	3.75
Lactic Acid, $CH_3CH(OH)COOH$	1.38×10^{-4}	3.86
Phenol, C_6H_5OH	1.28×10^{-10}	9.89
Propanoic Acid, CH_3CH_2COOH	1.30×10^{-5}	4.89



D-Glyceraldehyde

Association Constants and pK_b Values for Selected Monoprotic Weak Bases

Weak Base	K_b	pK_b
Ammonia, NH_3	1.8×10^{-5}	4.74
Dimethylamine, $(CH_3)_2NH$	5.9×10^{-4}	3.23

Dissociation Constants and pK_a Values for Selected Diprotic Weak Acids

Acid	K_{a1}	K_{a2}	pK_{a1}	pK_{a2}
Ascorbic Acid, $C_6H_8O_6$	1.0×10^{-5}	5.0×10^{-12}	5.00	11.30
Carbonic Acid, H_2CO_3	4.5×10^{-7}	5.6×10^{-11}	6.35	10.33
Malonic Acid, $HOOCCH_2COOH$	1.4×10^{-3}	2.0×10^{-6}	2.85	5.70
Succinic Acid, $HOOC(CH_2)_2COOH$	6.2×10^{-5}	2.3×10^{-6}	4.21	5.64
Tartaric Acid, $HOOCCH(OH)CH(OH)COOH$	1.3×10^{-3}	4.0×10^{-5}	2.89	4.40

Rate Law Equations

Order	Rate Law	Integrated Rate Law	Half-Life
First	$Rate = k[\mathrm{S}]$	$\ln[\mathrm{S}] - \ln[\mathrm{S}]_0 = -kt$	$t_{1/2} = \frac{\ln 2}{k} \approx \frac{0.693}{k}$
Second (S_1+S_1 or $[S_1]=[S_2]$)	$Rate = k[\mathrm{S}_1]^2$	$\frac{1}{[\mathrm{S}_1]_t} - \frac{1}{[\mathrm{S}_1]_0} = kt$	$t_{1/2} = \frac{1}{k[\mathrm{S}_1]_0}$
Second ($[S_1]\neq[S_2]$)	$Rate = k[\mathrm{S}_1][\mathrm{S}_2]$	$\ln\frac{[\mathrm{S}_2][\mathrm{S}_1]_0}{[\mathrm{S}_1][\mathrm{S}_2]_0} = k([\mathrm{S}_2]_0 - [\mathrm{S}_1]_0)t$	

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	