

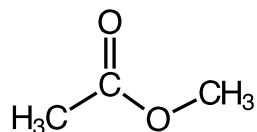
Instructions

- Please mark the Answer Sheet using **PENCIL ONLY**.
- Enter your **NAME** and **STUDENT NUMBER** on the Answer Sheet.
- The exam consists of 50 multiple-choice questions. Enter your answers on the Answer Sheet.
- There is only 1 correct answer for each question.
- Please read each question **CAREFULLY**.
- Please protect your Answer Sheet from the view of other students.
- Scratch Paper is available at the back of the examination.
- All test material must be returned at the end of the exam.

1. _____ is the most abundant biomolecule in most cells.

- A) Lipid
- B) Nucleic acid
- C) Carbohydrate
- D) Protein
- E) ATP

2. Where will a thiolate anion ($-S^-$) attack the following ester?



- A) At the carbonyl oxygen.
- B) At the ester oxygen.
- C) At the carbonyl carbon.
- D) At a methyl carbon.
- E) At a methyl hydrogen.

3. _____ is the energy available to do work at constant temperature and pressure.

- A) Potential Energy
- B) Kinetic Energy
- C) Entropy
- D) Gibb's Free Energy
- E) Heat Energy

4. After shaking, the oil and vinegar in a salad dressing spontaneously separate because _____

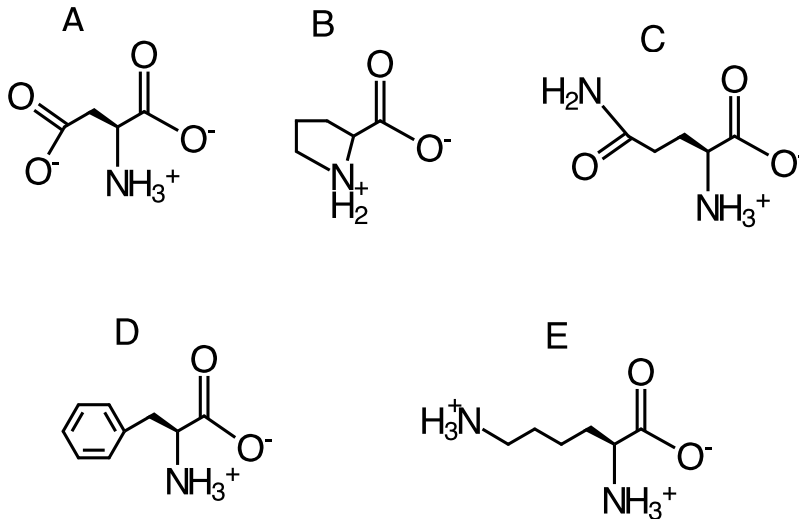
- A) the pH of the vinegar decreases during the separation of the components.
- B) water entropy increases and the free energy of the mixture decreases during the separation of the components.
- C) water entropy and the free energy of the mixture are lower after the components separate.
- D) upon separation the enthalpy of the mixture is highest.
- E) water entropy and oil enthalpy of the mixture are lower after the components separate.

5. 1 mL of 6 M HCl is added to 100 mL of water. What is the new pH?

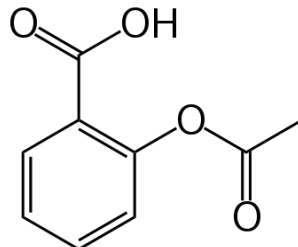
- A) 0.22
- B) 1.22
- C) 2.81
- D) 6.00
- E) None of the above.

6. What is the pH of a 100 mL solution of 100 mM acetic acid at pH 3.2 following addition of 5 mL of 1 M NaOH? The pK_a of acetic acid is 4.70.
- 3.20.
 - 4.65.
 - 4.70.
 - 4.75.
 - 9.60.

7. Identify the amino acid phenylalanine.



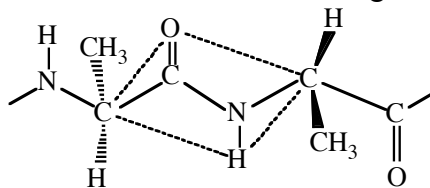
8. The structure of aspirin (acetyl salicylic acid) is shown below. The pK_a of the carboxyl group is 3.5. In order to be absorbed into cells the drug must cross a cellular membrane. Neutral molecules cross easily whereas charged molecules pass only with difficulty. Identify the **correct** statement below:



- Aspirin will easily pass into cells from saliva with a pH of 7.4.
 - Aspirin will easily pass into cells from the blood where the pH is 7.35.
 - Aspirin will easily pass into cells from cerebrospinal fluid with a pH of 7.33.
 - Aspirin will easily pass out of lysosomes where the pH is 5.
 - Aspirin will easily pass into gastric cells from the stomach with a pH of 1.
9. The pK_a 's of the amino acid Lysine are: 2.18, 8.95, and 10.53. What is the pI of Lysine?
- 3.38
 - 4.17
 - 6.65
 - 9.74
 - 10.13
10. In ion exchange chromatography amino acids are eluted from cationic or anionic functional groups _____
- owing to differences in the sizes of the amino acids.
 - by the application of an electric field.
 - by changing the pH of the elution buffer.
 - by reaction with Ninhydrin.
 - by partitioning between a hydrophobic stationary phase and a hydrophilic

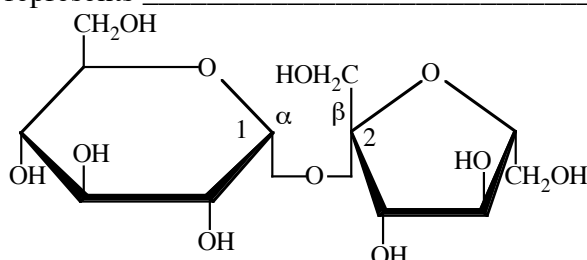
mobile phase.

11. Quaternary structure is defined as:
- The way in which separate folded monomeric protein subunits associate to form oligomeric proteins.
 - The sequence of amino acids.
 - Hydrogen bonding interactions between adjacent amino acid residues in helical or pleated segments.
 - A classification of fibrous proteins.
 - The folding of a single polypeptide chain in three-dimensional space.
12. Identify the **incorrect** statement about the following structure:



- It illustrates the concept of tautomerism.
 - Nitrogen lone pair electron delocalization results in the planar nature of the peptide bond.
 - Both C^α, the carbonyl C and O, and the amide N and H all lie in a plane.
 - The peptide bond is planar, trans and rigid.
 - The peptide bond joins two amino acids.
13. Identify the **correct** description of hydrogen bonding in an α -helix:
- $C=O_i \cdots H-N_i$
 - $C=O_i \cdots H-N_{i+1}$
 - $C=O_i \cdots H-N_{i+2}$
 - $C=O_i \cdots H-N_{i+3}$
 - $C=O_i \cdots H-N_{i+4}$
14. An enzyme following Michaelis-Menten kinetics has a maximum initial velocity of 375 nanomoles per second. An initial velocity is measured at 12 nanomolar substrate concentration and is found to be 187.5 nanomoles per second. What is the substrate concentration when the initial velocity of the reaction is 100 nanomoles per second?
- 0.31 nanomolar
 - 4.36 nanomolar
 - 8.33 nanomolar
 - 12.0 nanomolar
 - 375 nanomolar
15. Which of the following processes is **NOT** associated with enzyme regulation?
- Competitive non-covalent binding of molecules having similar steric and electronic properties to those of the substrate.
 - Proteolytic cleavage of the enzyme.
 - Covalent binding of small molecules such as antibiotics.
 - Denaturation by detergent.
 - Allosteric non-covalent binding of molecules that may have very different steric and electronic properties to those of the substrate.

16. For any enzyme that follows simple Michaelis-Menten kinetics, when the initial velocity of the reaction is $1/5$ of V_{max} what is the Substrate concentration?
- $K_M \ll [S]$
 - $K_M = 1/5[S]$
 - $K_M = 4[S]$
 - $K_M = 5[S]$
 - $K_M = [S]$
17. In an experiment to characterize an enzyme, high substrate concentrations fail to elevate the initial velocity of the reaction. What conclusion can be made?
- The enzyme is saturated with substrate.
 - The enzyme is following Michaelis-Menten kinetics.
 - The enzyme is following Allosteric kinetics.
 - The enzyme is inhibited by high substrate concentrations.
 - None of the above.
18. Which statement **correctly** describes the hydrolysis of a peptide bond by chymotrypsin?
- The negative charge on the transition state is neutralized by groups in the protein.
 - A covalent intermediate forms between the N-terminus of the substrate and the His in the catalytic triad.
 - The enzyme behaves as an acid-catalyst only.
 - Water is not a reactant.
 - Electrons flow out of the substrate and into the enzyme, and then back again.
19. The following represents _____



- a non-reducing disaccharide.
 - a disaccharide consisting of aldohexoses.
 - a disaccharide consisting of aldoketoses.
 - a monosaccharide.
 - cellulose.
20. Identify the following molecules.
- $$\begin{array}{c}
 \text{H}-\text{C}=\text{O} \\
 | \\
 \text{HC}-\text{OH} \\
 | \\
 \text{HC}-\text{OH} \\
 | \\
 \text{HC}-\text{OH} \\
 | \\
 \text{CH}_2\text{OH}
 \end{array}$$

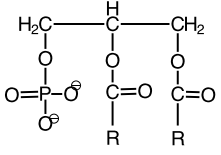
i

$$\begin{array}{c}
 \text{H}_2\text{C}-\text{OH} \\
 | \\
 \text{C}=\text{O} \\
 | \\
 \text{H}_2\text{C}-\text{OH}
 \end{array}$$

ii

$$\begin{array}{c}
 \text{CH}_2\text{OH} \\
 | \\
 \text{C}=\text{O} \\
 | \\
 \text{HO}-\text{CH} \\
 | \\
 \text{HC}-\text{OH} \\
 | \\
 \text{HC}-\text{OH} \\
 | \\
 \text{CH}_2\text{OH}
 \end{array}$$

iii
- i = *D*-glucose; ii = *D*-fructose; iii = *L*-ribose
 - i = *D*-fructose; ii = *D*-glucose; iii = *D*-ribose
 - i = *D*-ribose; ii = dihydroxyacetone; iii = *D*-fructose
 - i = *L*-fructose; ii = *D*-glyceraldehyde; iii = *D*-glucose
 - i = *D*-glucose; ii = *D*-glyceraldehyde; iii = *L*-fructose

21. Chitin, the main constituent of arthropod exoskeleton consists mainly of _____
 A) cross-linked protein chains.
 B) stearic acid.
 C) amylopectin.
 D) fructans and levans.
 E) a linear chain of N-acetylglucosamines linked $\beta 1 \rightarrow 4$.
22. Identify the **correct** statement:
 A) In ribose, 6-membered rings are more stable than 5-membered rings.
 B) The linear chain form of glucose never exists in solution.
 C) Mutarotation is caused by a change in the genetic storage material DNA.
 D) Reduction of glucose yields glucuronic acid.
 E) Intramolecular and intermolecular hemiketal formation results in the formation of a new chiral centre.
23. Identify the following compound:

 A) Cholesterol
 B) Stearic acid
 C) Ubiquinone
 D) Vitamin E
 E) Phosphatidic Acid
24. Sphingolipids are derivatives of _____.
 A) glycerol
 B) serine
 C) choline
 D) fatty acids
 E) isoprene
25. High serum cholesterol is a risk factor for _____.
 A) mutations
 B) scurvy
 C) atherosclerosis
 D) viral infections
 E) Vitamin A deficiency
26. Natural and artificial bilayers undergo phase transitions. At high temperatures the lipids exist in a i phase with ii fatty acid chains and at low temperatures the fatty acid chains become iii in the iv phase.
 A) i = solid; ii = ordered; iii = disordered; iv = gas.
 B) i = gel; ii = disordered; iii = ordered; iv = liquid crystalline.
 C) i = solid; ii = ordered; iii = liquid; iv = disordered.
 D) i = liquid; ii = ordered; iii = disordered; iv = gas.
 E) i = liquid crystalline; ii = disordered; iii = ordered; iv = gel.
27. Cytochrome c is an electron transport protein and _____.
 A) peripheral membrane protein.
 B) active transport protein.
 C) second messenger.
 D) proton pump.
 E) porin.

28. Deamination of _____ yields _____.
- A) Guanine; Thymine
 - B) Thymine; Uracil
 - C) Adenine; Thymine
 - D) Cytosine; Uracil
 - E) Uracil; Guanine
29. Which of the following sequences will form a hairpin loop structure?
- A) (5') UGCATTTAGCAATCATTTA(3').
 - B) (5') TGGCACGGCAATCCGTGCTG (3').
 - C) (5') GCACGGCAATCGGAATT (3').
 - D) (5') UGAUAGCAAC(3').
 - E) (5') GCCCGGCAATCUCCCU (3').
30. Identify the catalytic component of the ribosome.
- A. Fe
 - B. Protein
 - C. DNA
 - D. Enzyme
 - E. RNA
31. Transcription refers to which of the following processes?
- A) The synthesis of proteins from information encoded in RNA.
 - B) The synthesis of RNA from information encoded in DNA.
 - C) The duplication of DNA in preparation for cell division.
 - D) The synthesis of DNA from information encoded in RNA.
 - E) The synthesis of proteins from information encoded in DNA.
32. Identify the **correct** statement about nucleic acids.
- A) Transfer RNA molecules encode amino acid sequences.
 - B) Most eukaryotic organisms use RNA as their genetic storage material.
 - C) Some viruses use RNA as their genetic storage material.
 - D) Nucleic acids are principally used as energy-storage materials.
 - E) Nucleic acids undergo important oxidation-reductions reactions.
33. Triosephosphate isomerase catalyzes the interconversion of dihydroxyacetone phosphate and D-glyceraldehyde-3-phosphate. The free energy change for the reaction under standard conditions is +7.5 kJ/mol. What is the equilibrium constant for the reaction given that $R = 8.3 \text{ J/mol}\cdot\text{K}$ and $T = 298 \text{ K}$?
- A) 0.05
 - B) 20.7
 - C) 0.000928
 - D) 1077.1
 - E) 0.99
34. $\text{ADP} + \text{H}_2\text{O} \rightarrow \text{AMP} + \text{P}_i$ is a highly exergonic reaction releasing about 33 kJ/mol of free energy under standard conditions. This reaction proceeds slowly in water because _____
- A) the water covalent bonds are difficult to break.
 - B) free energy is not really "free".
 - C) the concentration of water is very high.
 - D) the temperature is very low in water under standard conditions.
 - E) the transition-state free energy is very high in the absence of an enzyme.

35. Identify the reaction carried out only by photosynthetic autotrophs:
- $(C_6H_{10}O_5)_n + 6nO_2 \rightarrow + 6nCO_2 + 5nH_2O$
 - $6CO_2 + 6H_2O \rightarrow (CH_2O)_6 + 6O_2$
 - $NADH + H^+ + \frac{1}{2} O_2 \rightarrow H_2O + NAD^+$
 - $(CH_2O)_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$
 - $ATP + H_2O \rightarrow AMP + PP_i$
36. If reactants and products are present at 1 M at standard temperature and pressure the direction of a biochemical reaction can be predicted according to which combination of standard free energy changes and equilibrium constants?
- When K'_{eq} is = 1 and $\Delta G'^0$ is 0 the reaction spontaneously moves in the forward direction.
 - When K'_{eq} is > 1 and $\Delta G'^0$ is negative the reaction spontaneously moves in the reverse direction.
 - When K'_{eq} is = 1 and $\Delta G'^0 = 0$ the reaction spontaneously moves in the reverse direction.
 - When K'_{eq} is < 1 and $\Delta G'^0$ is positive the reaction spontaneously moves in the reverse direction.
 - When K'_{eq} is > 1 and $\Delta G'^0$ is positive the reaction spontaneously moves in the reverse direction.
37. Which enzyme results in the splitting of a 6-carbon ketose into a 3-carbon ketose and a 3-carbon aldose?
- Phosphohexose isomerase
 - Triose-phosphate-isomerase
 - Hexokinase
 - Fructose-1,6-bisphosphate aldolase
 - Phosphoglycerate mutase
38. Which reaction is accompanied by the formation of NADH?
- $Glucose + ATP \rightarrow Glucose-6\text{ phosphate} + ADP + H^+$
 - $Dihydroxyacetone-phosphate \rightleftharpoons D-Glyceraldehyde-3-phosphate$
 - $Glyceraldehyde-3-phosphate + PO_4^{3-} \rightleftharpoons 1,3-bisphosphoglycerate$
 - $Phosphoenolpyruvate + H^+ + ADP \rightarrow Pyruvate + ATP$
 - $2-Phospho-glycerate \rightleftharpoons Phosphoenolpyruvate + H_2O$
39. The purpose of anaerobic lactic acid fermentation is _____
- to oxidize NADH.
 - to reduce the pH of muscle.
 - to metabolize lactate.
 - to slow down glycolysis so that glycolytic intermediates can be used for anabolism.
 - to oxidize pyruvate.
40. Which of the following is NOT derived from a Vitamin?
- Lipoic Acid
 - Thiamine
 - Coenzyme A
 - Nicotinamide
 - FAD

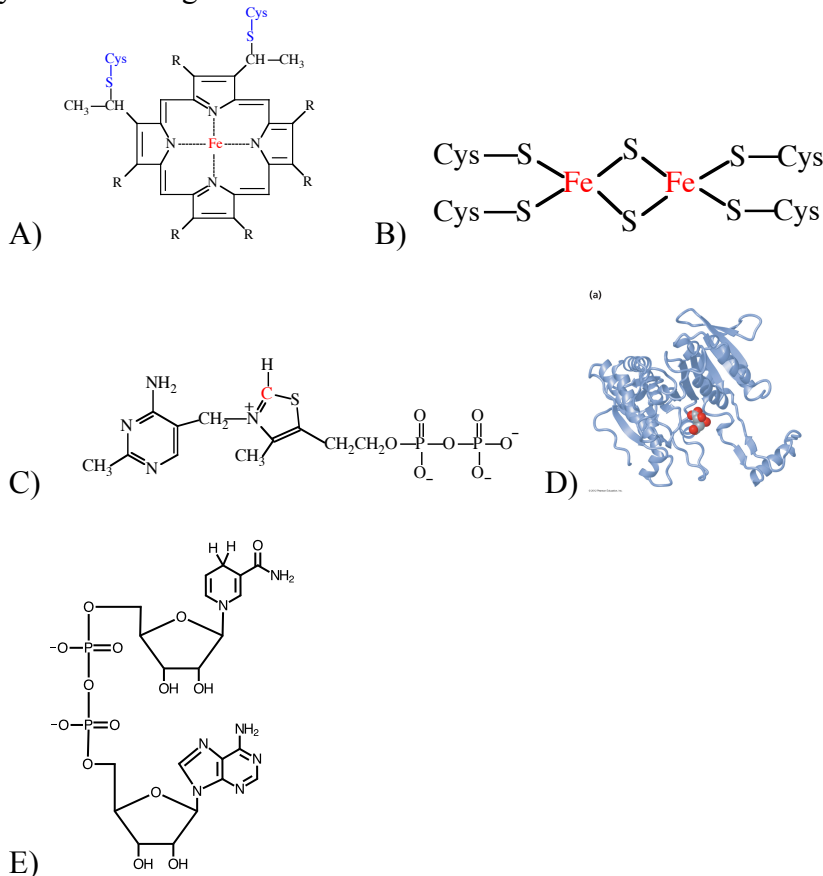
41. The standard reduction potentials (E'°) for the following half reactions are given.



Calculate the equilibrium constant for the coupled redox reaction given that $R = 8.3 \text{ J/mol}\cdot\text{K}$, $T = 298 \text{ K}$, and \mathcal{F} (Faraday constant) = $96.4 \text{ kJ/volt}\cdot\text{mol}$.

- A) 2.00×10^{-28}
 B) -4.4
 C) 9.99×10^{99}
 D) 8.85×10^{26}
 E) 1.14×10^{-27}
42. Which set of enzymes catalyze oxidative decarboxylations?
 A) pyruvate dehydrogenase; succinyl CoA-synthetase; ATP synthase.
 B) α -ketoglutarate dehydrogenase; pyruvate dehydrogenase; isocitrate dehydrogenase.
 C) isocitrate dehydrogenase; glyceraldehyde-3-phosphate dehydrogenase; aconitase.
 D) glyceraldehyde-3-phosphate dehydrogenase; succinyl CoA-synthetase; aconitase.
 E) succinate dehydrogenase; pyruvate dehydrogenase; succinyl CoA-synthetase.
43. Which enzyme is inhibited by ATP, acetyl-CoA, NADH, fatty acids and CO_2 and activated by pyruvate, AMP, CoA, and NAD^+ ?
 A) Hexokinase.
 B) Succinyl-CoA Synthetase.
 C) Pyruvate dehydrogenase complex.
 D) Phosphohexose isomerase.
 E) Succinate dehydrogenase.
44. What fraction of TCA cycle steps conserve the free energy of oxidation in the form of a high-energy phosphate bond?
 A) 12.5%.
 B) 25%.
 C) 37.5%.
 D) 50%.
 E) 62.5%.
45. The conversion of pyruvate to acetyl-CoA is catalyzed by _____ i _____ and utilizes _____ ii _____ as a cofactor to aid in C–C bond cleavage.
 A) i = malate dehydrogenase; ii = lipoic acid
 B) i = citrate synthase; ii = coenzyme A
 C) i = pyruvate dehydrogenase complex; ii = TPP
 D) i = aconitase; ii = NADH
 E) i = α -ketoglutarate dehydrogenase complex; ii = TPP
46. Identify the **correct** statement about the mitochondrion:
 A) The mitochondrion contains a highly permeable inner membrane and an impermeable outer membrane.
 B) The mitochondrion likely arose by a process of symbiogenesis.
 C) The mitochondrion stores all the genetic information in a prokaryotic cell.
 D) The mitochondrion is the site where glycolysis takes place.
 E) The mitochondrial matrix contains the enzymes of the electron transport chain.

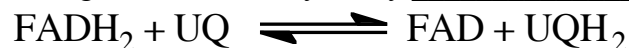
47. Identify the heme ring.



48. Which molecule diffuses through the inner membrane of the mitochondrion delivering electrons in the electron transport chain (ETC)?

- A) Succinic acid.
- B) Nicotinamide adenine dinucleotide.
- C) Flavine adenine nucleotide.
- D) Lipoic acid.
- E) Ubiquinone.

49. The following reaction is catalyzed by _____



- A) Complex I of the ETC.
- B) Complex II of the ETC.
- C) Complex III of the ETC.
- D) Complex IV of the ETC.
- E) ATP Synthase of the ETC.

50. In the electron transport chain, 4 electrons are required to reduce one O₂ molecule to 2 H₂O molecules. Identify the **correct** statement about the origin of the 4 electrons.

- A) The 4 electrons originate in 4 NADH molecules and are passed to 2 Cytochrome c molecules.
- B) The 4 electrons originate in 1 NADH molecule and are passed to 2 Cytochrome c molecules.
- C) The 4 electrons originate in 4 NADH molecules and are passed to 4 Cytochrome c molecules.
- D) The 4 electrons originate in 2 NADH molecules and are passed to 2 Cytochrome c molecules.
- E) The 4 electrons originate in 2 NADH molecules and are passed to 4 Cytochrome c molecules.

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December 19, 2016

9:00 am – 11:00 am

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CHEM / MBIO 2770

Elements of Biochemistry I

Final Examination

University College Great Hall

Seats 1-128

Examiner: J. O'Neil

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Scratch Paper

