INFORMATION THAT MAY BE USEFUL FOR THE EXAM

Abbreviations for Amino Acids			
Amino Acid	3-Letter Abbreviation	Amino Acid	3-Letter Abbreviation
Alanine	Ala	Leucine	Leu
Arginine	Arg	Lysine	Lys
Asparagine	Asn	Methionine	Met
Aspartic Acid	Asp	Phenylalanine	Phe
Cysteine	Cys	Proline	Pro
Glutamine	Gln	Serine	Ser
Glutamic Acid	Glu	Threonine	Thr
Glycine	Gly	Tryptophan	Trp
Histidine	His	Tyrosine	Tyr
Isoleucine	Ile	Valine	Val

Ionizable Group	pKa
α-COOH of any aa	2
β-COOH of Asp	4
γ-COOH of Glu	4
imidazole of His	6
SH of Cys	8
α-NH_2 of any aa	9
phenolic OH of Tyr	10
ϵ-NH_2 of Lys	10
guanidino of Arg	12

Tables of Logarithmic Relationships

	Decimal									
Number	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
1.	.00	.04	.08	.11	.15	.18	.20	.23	.26	.28
2.	.30	.32	.34	.36	.38	.40	.41	.43	.45	.46
3.	.48	.49	.51	.52	.53	.54	.56	.57	.58	.59
4.	.60	.61	.62	.63	.64	.65	.66	.67	.68	.69
5.	.70	.71	.72	.72	.73	.74	.75	.76	.76	.77
6.	.78	.79	.79	.80	.81	.81	.82	.83	.83	.84
7.	.85	.85	.86	.86	.87	.88	.88	.89	.89	.90
8.	.90	.91	.91	.92	.92	.93	.93	.94	.94	.95
9.	.95	.96	.96	.97	.97	.98	.98	.99	.99	1.00
10.	1.00					logs				

E.g. log 3.5 = 0.54

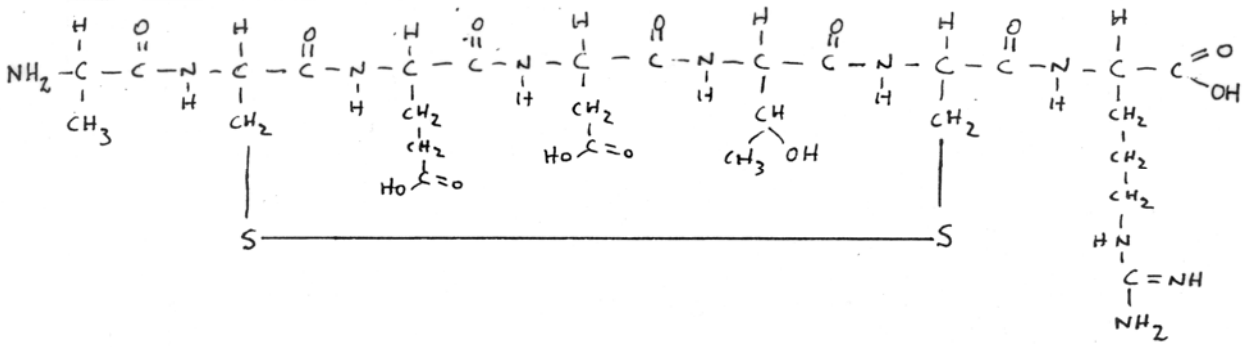
Reminder: How to form logs of multiples .....

log 35 = log (3.5×10^1) = (log 3.5 + log 10^1) = (0.54 + 1) = 1.54

log 350 = log (3.5×10^2) = (log 3.5 + log 10^2) = (0.54 + 2) = 2.54

log 0.35 = log (3.5×10^{-1}) = (log 3.5 + log 10^{-1}) = (0.54 - 1) = - 0.46

Questions 1-4 refer to the molecule shown below.



1) How many **functional groups** in the peptide shown above is/are basic (can accept a proton (H^+))?

A) 0
B) 1
C) 2
D) 3
E) 4

2) Although the free sulfhydryl group of Cys residues exhibits the property of a weak acid, it loses the ionizable proton upon oxidation into a disulfide bond. Given this information and the pKa values in the table on page 2 of this exam, what will be the net charge of the above peptide at pH 7?

A) -2
B) -1
C) 0
D) +1
E) +2

3) In the peptide shown above, which residue(s) would be regarded as secondary amino acids?

A) amino acids #1 and #7
B) amino acids #2 and #6
C) amino acids #3 and #5
D) amino acid #4
E) none

4) Considering only the side chains in the above peptide, which of the amino acids in the peptide **CANNOT** undergo hydrogen bonding?

A) amino acid #1
B) amino acid #3
C) amino acid #4
D) amino acid #5
E) amino acid #7

5) A patient with an enteropathy (intestinal disease) produced large amounts of ammonia (NH_3) from bacterial overgrowth in the intestine. The ammonia was absorbed through the intestine into the portal vein and entered the circulation. Which of the following is a likely consequence of his ammonia absorption, given that the pKa value of the equilibrium below is 9.2?

$$NH_4^+ \longleftrightarrow NH_3 + H^+$$

A) A decrease of blood pH.
B) Conversion of ammonia to ammonium ion in the blood.
C) A decreased concentration of bicarbonate in the blood.
D) Kussmaul respiration.
E) Increased expiration of CO_2.

6) Which of the following describes a universal property of buffers?

A) Buffers are usually composed of a mixture of strong acids and strong bases.
B) Buffers work best at the pH at which they are completely dissociated.
C) Buffers work best at the pH at which they are 50% dissociated.
D) Buffers work best at one pH unit lower than the pKa value.
E) Buffers work equally well at all concentrations.

7) Which type of interactions (forces) found in proteins is **most appropriately** matched with the feature that follows?

A) ionic bonds: α-helical secondary structure
B) peptide bonds: association of subunits to form quaternary structure
C) hydrophobic interactions: tertiary structure
D) hydrogen bonds: covalent cross-links between polypeptides
E) cation-anion interactions: β-pleated sheet

8) Alzheimer's disease is caused by the accumulation of the amyloid β (Aβ) protein in brain regions serving memory and cognition. Interestingly, $A\beta_{42}$, a peptide which contains just two extra amino acids at the C-terminus than $A\beta_{40}$, is considered the "toxic" species in Alzheimer's disease because it tends to aggregate more than its shorter counterpart, $A\beta_{40}$. The two additional C-terminal residues in $A\beta_{42}$ are isoleucine and alanine. Based on your understanding of amino acid properties, how might these two extra residues lead to enhanced aggregation of the peptide?

A) The additional two residues may participate in hydrophilic interactions which facilitate protein aggregation
B) the additional two residues may participate in hydrophobic interactions which facilitate protein aggregation
C) the additional two residues may participate in polar interactions which facilitate protein aggregation
D) the additional two residues may participate in disulfide bonding to facilitate protein aggregation
E) none of the above

9) Carbon monoxide (CO) is toxic because:

A) It induces the chloride shift.
B) It binds competitively to the heme group and thus lowers the amount of O_2 bound.
C) It is a negative allosteric effector and lowers the affinity of hemoglobin for oxygen.
D) Aqueous CO is acidic and causes premature release of oxygen.
E) It directly displaces 2,3-diphosphoglycerate.

10) The dissociated subunits of hemoglobin (α-chain alone or β-chain alone) have a much lower P_{50} value for oxygen than the intact tetramer. Why?

A) 2,3-diphosphoglycerate (DPG) can interact much more readily with the dissociated subunits.
B) The heme units are in a higher oxidation state.
C) Carbamino reaction of exposed amino termini occurs more readily.
D) The Bohr effect operates more effectively.
E) Subunit interactions are required for the negative allosteric effects that regulate oxygen affinity.

11) Which of the following best describes the situation that would be most favorable to release of O_2 at peripheral tissues? ("High" and "low" are relative terms indicating comparison with the lung.)

	pH	**pCO_2**	**pO_2**
A)	low	high	high
B)	low	high	low
C)	high	high	low
D)	high	low	low
E)	high	high	high

12) In this question, "up" means higher than and "down" means lower than the normal values of pH = 7.4, $[HCO_3^-]$ = 24 mM, and pCO_2 = 40 mm Hg. In partially compensated metabolic alkalosis:

	pH	**$[HCO_3^-]$**	**pCO_2**
A)	up	up	down
B)	down	up	up
C)	up	up	up
D)	down	up	down
E)	down	down	down

Questions 13-16 refer to the case described below.
Miss W., 14-years old, was admitted to a children's hospital emergency room in a coma. Her mother stated that the girl had been in good health until approximately two weeks ago, when she developed a sore throat and moderate fever. She has not felt well since. Several days before admission, she began to complain of undue thirst and also started to get up several times during the night to urinate. On the day of admission, Miss W. had started to vomit and had become drowsy. On examination, Miss W. appeared dehydrated; her skin was cold. She was breathing a deep sighing manner (Kussmaul respiration). Her breath had a fruity odor.
Blood pressure: 90/60; pulse rate: 115/min.

Test	Admission	Normal Values
Hemoglobin (g/dL)	15	12 – 16
pH	???	7.35 – 7.45
Total CO_2 content	???	26 – 27
pCO_2 (mm Hg)	20	35 – 45
pO_2 (mm Hg)	95	95 – 100
bicarbonate (mM)	???	22 – 26
glucose (mg/dL)	450	76 – 110
sodium (meq/L)	136	136 – 145
potassium (meq/L)	5.5	3.5 – 5.0
chloride (meq/L)	100	100 – 106
anion gap (meq/L)	35.5	10-16

Notes: (a) pK_a of bicarbonate-CO_2 buffer, 6.1;
(b) solubility coefficient for CO_2 at 37°C, 0.03 mM/mmHg.

13) Calculate the Total CO_2 content in the patient's blood at the time of admission. Your calculated value is **closest** to:

A) 1 mM
B) 4 mM
C) 7 mM
D) 10 mM
E) 14 mM

14) Calculate the patient's blood pH at the time of admission. Your calculated value is **closest** to:

A) 6.9
B) 7.1
C) 7.4
D) 7.7
E) 8.0

15) At the time of admission, what is Miss W.'s acid-base status?

A) uncompensated respiratory alkalosis
B) fully compensated respiratory acidosis
C) partially compensated metabolic alkalosis
D) partially compensated metabolic acidosis
E) acid-base normalcy

16) Which of the following suggests that Miss W. has begun compensation for her present crisis?

A) Lower than normal pO_2
B) Lower than normal anion gap
C) Lower than normal pCO_2
D) Higher than normal blood glucose
E) All of the above

17) If an enzyme was removed from a reaction that it catalyzed, which of the following statements would be true regarding the reaction left to proceed in an uncatalyzed way:

A) the reaction rate would increase
B) the ΔG would increase
C) the ΔG would decrease
D) the activation energy would increase
E) the activation energy would decrease

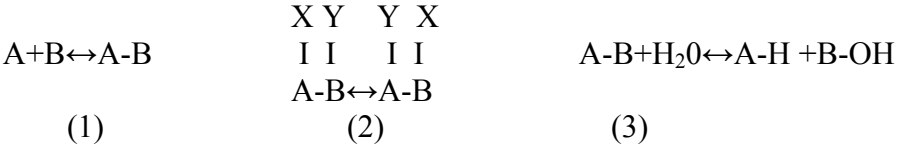
18) Which of the following generalizations about enzymes is **incorrect**?

A) protein molecules can serve as enzymes
B) enzymes and their substrates are usually associated noncovalently
C) enzymes accelerate reactions by stabilizing the transition state
D) enzymes often require non-protein components for activity
E) enzymes alter the equilibrium of a chemical reaction

19) Which of the following statements best describes a characteristic feature of an enzyme that obeys Michaelis-Menten kinetics?

A) The velocity of the reaction is independent of the concentration of the enzyme.
B) The enzyme velocity is at its maximal rate when all of the substrate molecules in solution are bound by the enzyme.
C) The enzyme velocity is at its maximal rate when 50% of the enzyme molecules contain bound substrate.
D) The enzyme velocity is at one-half the maximal rate when 50% of the enzyme molecules contain bound substrate.
E) The enzyme velocity is at one-half the maximal rate when 100% of the enzyme molecules contain bound substrate.

20) The enzymes that catalyze reactions 1, 2, and 3, respectively are called:



A) ligase, transferase, oxidoreductase
B) ligase, isomerase, hydrolase
C) ligase, lyase, hydrolase
D) transferase, lyase, hydrolase
E) transferase, isomerase, oxidoreductase

Questions 21 and 22 refer to the enzyme glucokinase, which catalyzes the reaction

glucose + ATP ◄———► glucose 6-phosphate + ADP

[hint: you might find it easier to answer these questions if you "crank out the numbers."]

21) The enzyme's Km value for glucose is 5 mM. The concentration of the substrate, glucose, is basically the level of blood glucose. Using the information below, which of the following statements best represents the activity of glucokinase before and after a high carbohydrate meal (everything else being equal)?

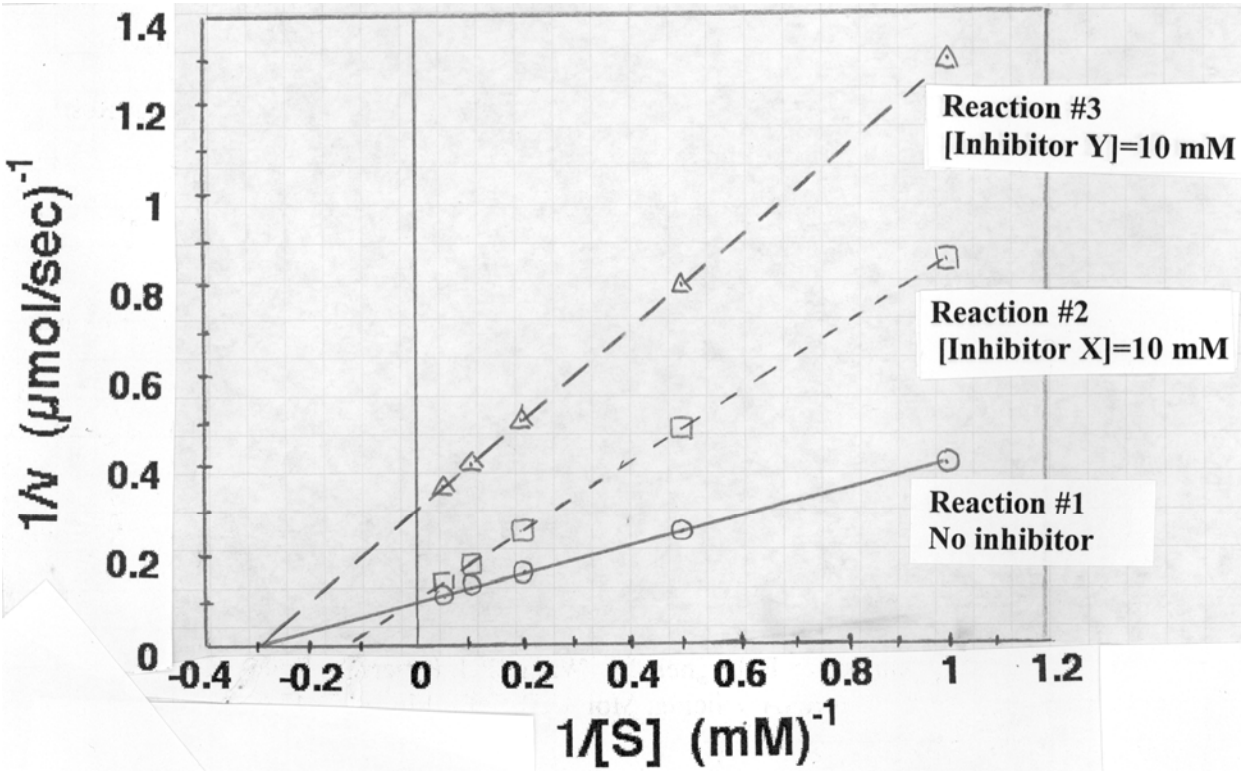
	[blood glucose]	**initial velocity v**
Before the meal (fasting)	**4 mM**	**???**
After the meal	**20 mM**	**???**

A) Glucokinase will work about twice as fast after a carbohydrate meal as during fasting.
B) Glucokinase will work 10 times faster after a carbohydrate meal than before the meal.
C) Glucokinase will work 10 times slower after a carbohydrate meal than before the meal.
D) Glucokinase will work about five times slower after a carbohydrate meal as during fasting.
E) There will be no difference in how fast glucokinase works before and after the carbohydrate meal.

22) The glucokinase of a patient with MODY (maturity onset diabetes of the young) has a mutation replacing a leucine with a proline. This resulted in changes in both the Km and Vmax values of the enzyme, as tabulated below. Which of the following statements best describes the patient's glucokinase compared to the normal enzyme?

	Km (mM) for glucose	**Vmax (U/mg protein)**
Normal (wild-type)	5	93
Patient (mutant)	2.2	0.2

A) The patient's enzyme requires a lower concentration of glucose to reach ½ Vmax.
B) The patient's enzyme is faster than the normal enzyme at concentrations of glucose < 2.2 mM.
C) The patient's enzyme is faster than the normal enzyme at concentrations ~2.2 mM.
D) At near saturating glucose concentration, the patient would need 10 times more enzyme than normal to achieve normal rates of glucose phosphorylation.
E) As blood glucose levels increase after a meal from a fasting value of 4 mM to 10 mM, the rate of the patient's enzyme will increase more than the rate of the normal enzyme.



23) Shown above are the rates, **v** (µmol/sec), at which an enzyme converts its substrate to product as a function of the substrate concentration **[S]**, plotted in the Lineweaver-Burk format. Reaction #1 represents data (circles) for the uninhibited reaction. Reaction #2 represents data (squares) collected in the presence of 10 mM of inhibitor X. Reaction #3 represents data (triangles) collected in the presence of 10 mM of inhibitor Y. The same amount of enzyme was used in each reaction.

	Reaction #1	**Reaction #2**	**Reaction #3**
Inhibitor	**none**	**X**	**Y**
[inhibitor]	**0**	**10 mM**	**10 mM**
Km (or Km') value	**3.3 mM**	**???**	**???**
Vmax (or Vmax') value	**10 µmol/sec**	**???**	**???**

Which of the following statement best represents the information provided?

A) When bound with inhibitor Y, the enzyme behaves like an allosteric enzyme.
B) The affinity of the enzyme for its substrate is decreased 10-fold by inhibitor Y.
C) The enzyme works much better in the presence of inhibitor X than in its absence.
D) Inhibitor X is a competitive inhibitor of the enzyme.
E) None of the three reactions obey Michaelis-Menten kinetics.

24) A chemist optimizes a chemical reaction such that product concentration exceeds the concentration of the reactants. What conclusions can be drawn about K_{eq} and ΔG^{O} in this reaction?

A) $K_{eq} > 1$, $\Delta G^{O} > 0$
B) $K_{eq} > 1$, $\Delta G^{O} < 0$
C) $K_{eq} < 1$, $\Delta G^{O} > 0$
D) $K_{eq} < 1$, $\Delta G^{O} < 0$
E) $K_{eq} = 1$, $\Delta G^{O} = 0$

25) The product label on the right is from a vitamin supplemented fiber bar. Hypothetically, a patient is relying on these fiber bars for all of their dietary vitamins. Which of the following statements accurately describes what you might tell this patient?

A) "You are at risk of developing scurvy"
B) "You should change your vitamin source if you plan on getting pregnant"
C) "You will probably begin developing signs of Beri-beri since these vitamins have little vitamin B1"
D) "The levels of B12 will make you susceptible to pernicious anemia"
E) "The ability of certain enzymes, such as transaminases, to carry nitrogen will not be affected by this diet"

Nutrition Facts

Serving Size: 25 pieces (100g)
Serving per container: 1

Amount per serving

Calories: 140
Calories from fat: 35

Vitamin	Amount	%RDI
Thiamine	(1.5 mg)	100
Riboflavin	(1.7 mg)	100
Niacin	(2.0 mg)	10
Pantothenate	(100 mg)	100
Pyridoxal	(0.4 mg)	8
Folate	(20 ug)	5
Cobalamin	(9 ug)	300
Biotin	(300 ug)	100
Ascorbate	(60 mg)	100

Questions 26 through 29 refer to the following reactions and their standard state free energy (A – E)

	REACTION	$\Delta G^{o'}$
A.	A + B → C + D	-3.5
B.	A + B → C + D	-1.4
C.	A + B → C + D	0.0
D.	A + B → C + D	1.4
E.	A + B → C + D	3.5

26) Which of the reactions will have the highest concentration of products if it is allowed to go to equilibrium under standard state conditions?

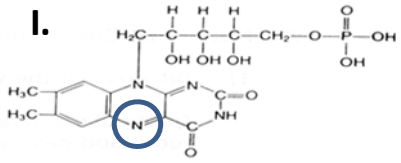
27) Inside the cell, [A] = 10M, [B] = 0.1 M, [C] = 1M, and [D] = 0.01M. Which of the above reactions will give a free energy change ($\Delta G'$) equal to -1.4 kcal/mol under these conditions (Given $\Delta G' = \Delta G^{o'} + 1.4 \log[\text{products}]/[\text{reactants}]$)?

28) Which of the above reactions would have an equilibrium constant (Keq) = 10

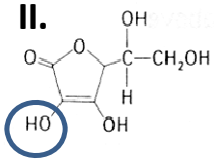
29) Which of the above reactions is at equilibrium under standard conditions?

Questions 30-32 refer to the following coenzyme derivatives (I – V)

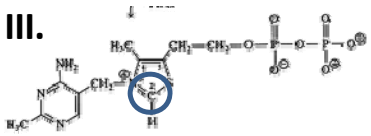
I.



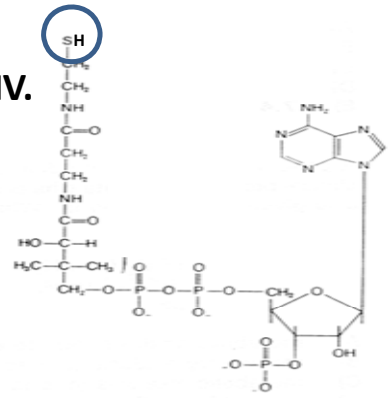
II.



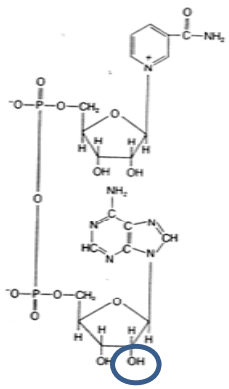
III.



IV.



V.



30) Which of the coenzyme derivatives are carriers of carbon?

A) I only
B) III only
C) I and II
D) III and IV
E) I and III

31) If the circles denote a potential active site, which coenzyme derivative is labeled incorrectly?

A) I
B) II
C) III
D) IV
E) V

32) A patient is brought into the clinic suffering from severe diarrhea, dermatitis, and is forgetful of normal daily things, such as the time and date (early stage dementia). While collecting the patient's history you learn that he started a new fad diet several weeks ago. Given the symptoms, you suspect a vitamin deficiency. Which of the coenzyme derivatives would you suspect is deficient in the patient's new diet?

A) I
B) II
C) III
D) IV
E) V

END OF EXAMINATION Tear off this sheet and save to check your answers.

Please remember to:

- Write in your **form letter** in the appropriate place on the **answer sheet**.
- **SIGN AND RETURN YOUR EXAMINATION** to an instructor **before leaving the exam room**.

FORM: A

1. _____	11. _____	21. _____	31. _____
2. _____	12. _____	22. _____	32. _____
3. _____	13. _____	23. _____	
4. _____	14. _____	24. _____	
5. _____	15. _____	25. _____	
6. _____	16. _____	26. _____	
7. _____	17. _____	27. _____	
8. _____	18. _____	28. _____	
9. _____	19. _____	29. _____	
10. _____	20. _____	30. _____	