

CHEM-643 Biochemistry

Name \_\_\_\_\_

Mid-term Examination

8:00 – 10:00 AM, Wednesday, 6 November 2013

Dr. H. White - Instructor

This examination will assess your learning, problem-solving skills, and ability to communicate clearly. Parts are intended to be challenging even to the best students in the class. Some of the questions will deal with material you have not seen before and is not in your text; however, those questions can be answered by applying basic principles discussed in the course.

There are 9 pages to this examination including this page.

- **Write your name on each new page.**
- Read every question so that you understand what is being asked. If you feel any question is unclear or ambiguous, clearly explain your answer or interpretation. Please call my attention to any errors you encounter.
- This examination is closed book. You may also refer to the metabolic pathway sheets available from the course website that you bring to the exam.
- Do not expose your answers to the scrutiny of your neighbors. Please fold under each page before you go on to the next.

Breakdown of the examination by sections:

I. Basic Bloom's basement	20 Points
II. Nomenclature and Reactions	20 Points
III. Problems	60 Points
<u>IV. Essays</u>	<u>20 Points</u>
Total	120 Points

Exam Statistics

Class Range

Class Mean

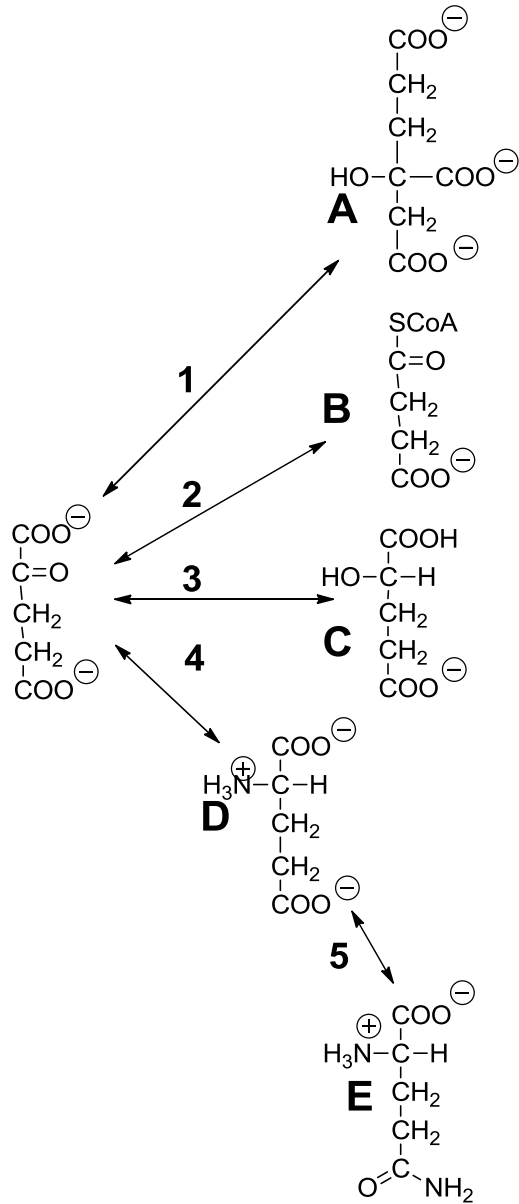
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**Part I - Basic Vocabulary and Working Knowledge** “Bloom’s Basement” (1 point each)

- \_\_\_\_\_ 1. Fatty acid precursor for prostaglandins.
- \_\_\_\_\_ 2. Coenzyme associated with formation of  $\beta$ -keto acids
- \_\_\_\_\_ 3. Free energy of hydrolysis of ATP is similar to that of \_\_\_\_.
- \_\_\_\_\_ 4. The “N” in NAD stands for \_\_\_\_.
- \_\_\_\_\_ 5. Six-carbon precursor of cholesterol and ketone bodies.
- \_\_\_\_\_ 6. Coenzyme associated with decarboxylation of  $\alpha$ -amino acids.
- \_\_\_\_\_ 7. Coenzyme associated with decarboxylation of  $\alpha$ -keto acids.
- \_\_\_\_\_ 8. Vitamin precursor for FAD.
- \_\_\_\_\_ 9. Vitamin recommended to reduce the incidence of neural tube defects, e.g. spina bifida.
- \_\_\_\_\_ 10. Term for organisms that require specific nutrients, e.g. vitamins, amino acids, that they cannot make.
- \_\_\_\_\_ 11. Metal ion found in nitrogenase other than iron.
- \_\_\_\_\_ 12. Pyruvate dehydrogenase and glycine cleavage enzyme have this sulfur-containing prosthetic group in common.
- \_\_\_\_\_ 13. Type of *metabolic* regulation characteristic of biosynthetic pathways.
- \_\_\_\_\_ 14. Enzyme providing the major metabolic point-of-entry of *reduced* nitrogen into living cells.
- \_\_\_\_\_ 15. Common name for C<sub>18:1</sub>
- \_\_\_\_\_ 16. Characteristic of enzyme reactions that produce NADPH.
- \_\_\_\_\_ 17. Compound that birds and reptiles use to dispose of excess nitrogen.
- \_\_\_\_\_ 18. Major/sole energy source for the brain of a well-fed human.
- \_\_\_\_\_ 19. Major source of energy for a weight lifter.
- \_\_\_\_\_ 20. A function of the pentose phosphate pathway other than to produce NADPH.

**Part III: Reactions of  $\alpha$ -ketoglutarate**

1 (20 Points Total). The diagram below shows five metabolites that are connected to  $\alpha$ -ketoglutarate by metabolic reactions. The arrows may but are *not* intended to indicate reversibility. Please identify the Compounds A to E, the names of enzymes associated with Arrows 1 – 5, any cofactors (if none, so state), and any additional substrates or products needed to create a balanced equation.



Metabolite Name

- A. \_\_\_\_\_
- B. \_\_\_\_\_
- C. \_\_\_\_\_
- D. \_\_\_\_\_
- E. \_\_\_\_\_

Enzyme Name

- 1. \_\_\_\_\_
- 2. \_\_\_\_\_
- 3. \_\_\_\_\_
- 4. \_\_\_\_\_
- 5. \_\_\_\_\_

Cofactors, if any

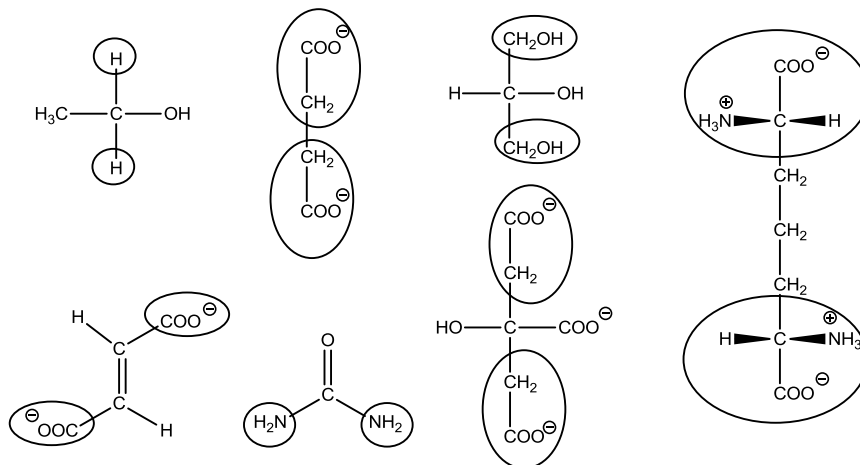
- 1. \_\_\_\_\_
- 2. \_\_\_\_\_
- 3. \_\_\_\_\_
- 4. \_\_\_\_\_
- 5. \_\_\_\_\_

Substrates & Products

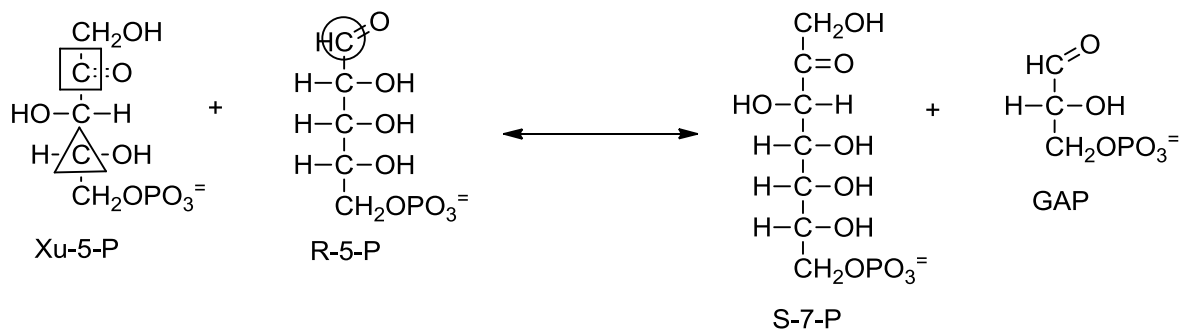
- 1. \_\_\_\_\_
- 2. \_\_\_\_\_
- 3. \_\_\_\_\_
- 4. \_\_\_\_\_
- 5. \_\_\_\_\_

**Part III: Problems and thought questions**

1. (7 Points) Each of the metabolic intermediates below is symmetrical in that one half of the molecule is like the other half as indicated by the ovals around corresponding parts. Enzymes can distinguish one half from the other half in some cases and not in others. **Put circles around** those molecules that an enzyme could distinguish the two half. **Put boxes around** those that an enzyme could not distinguish the halves.



2. (1 Point) What amino acid would result from decarboxylation of the compound at the far right above?
3. (6 Points) In the Pentose Phosphate Pathway, carbon-carbon bonds are made and broken as 3 five-carbon intermediates get converted into three- and six-carbon glycolytic intermediates. One of the reactions is shown below with three carbon atoms marked with a circle, square, or triangle. Show where those carbon atoms end up in the products of the reaction using the same symbols for corresponding carbon atoms.

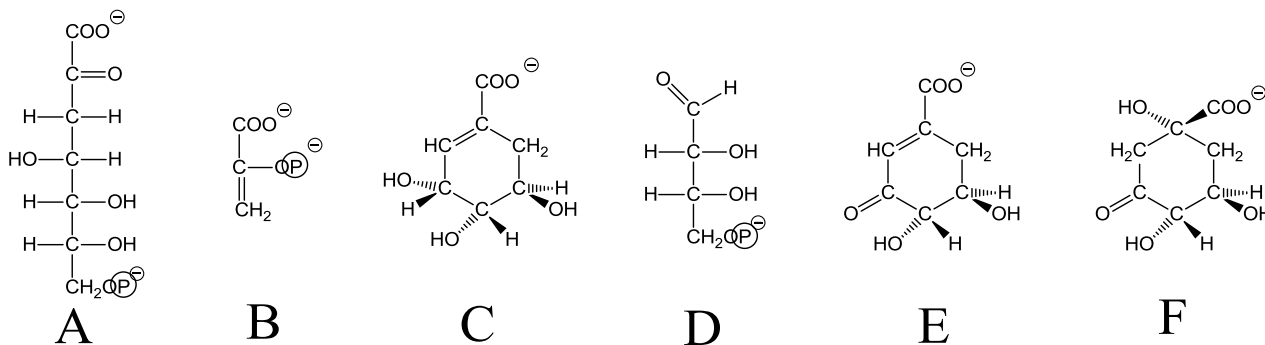


4. (6 Points) In glycolysis a molecule of fructose-1,6-bisphosphate (FBP) is split by the enzyme aldolase into one molecule of glyceraldehyde-3-phosphate (GAP) and one molecule of dihydroxyacetone phosphate (DHAP). Yet, in a cell, the concentrations of GAP and DHAP are not equal. Provide two reasons why the concentrations of these two glycolytic intermediates are not equal.

a.

b.

5. The biosynthesis of aromatic amino acids in bacteria and plants begins with the condensation of phosphoenol pyruvate (PEP) with erythrose 4-phosphate (E4P). The intermediates in the first part of this pathway are presented out of order below.



a. (1 Point) Draw a circle around (E4P).

b. (2 Points) Compound A is the product of condensing PEP with E-4-P. Circle the carbon atom in compound A that is derived from carbon 2 of E-4-P.

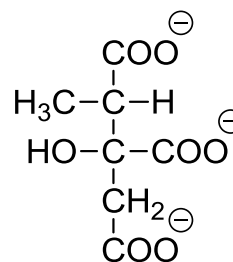
c. (2 Points) Compound A is converted to Compound F by an enzyme. Put an “X” on the carbon in compound F derived from carbon 2 of E4P.

d. (1 Point) Compound C is Shikimic acid. It is derived in a single step from one of the other compounds shown. Draw a box around the compound that would be the immediate precursor to C in the aromatic amino acid biosynthetic pathway.

e. (2 Points) What chemically has happened to the compound you have boxed to convert it to Compound C?

6. (6 Points total) The enzyme isoleucine racemase was added to a solution of 8 mM L-isoleucine and the reaction was allowed to go to equilibrium.
- a. (2 Points) What would be the expected concentrations of substrate and product at equilibrium for this reaction? Why?
- b. (2 Points) What would the expected equilibrium constant be for this reaction? Explain.
- c. (2 Points) What would be the expected  $\Delta G^{0'}$  for this reaction?

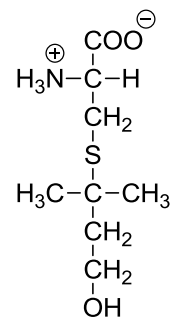
7. (6 Points) Patients with multiple carboxylase deficiency (aka- biotinidase deficiency) excrete much larger than normal amounts of a variety of organic acids including methyl citrate shown at the right.



- a. Assuming that citrate synthase is reacting with an accumulated analog of one of its natural substrates, show the reaction that would produce methyl citrate.

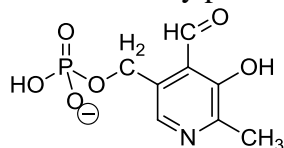
- b. (6 Points) How does biotinidase deficiency lead to the accumulation of the precursor to methyl citrate?

8. (14 Points total) Male cats in particular excrete as much as 90 mg/day of felinine (compound shown to the right), which they use to mark their territory. Felinine itself is not volatile and has little odor. However, microbes break it down into a volatile five-carbon thiol that has the distinctive odor associated with cats.



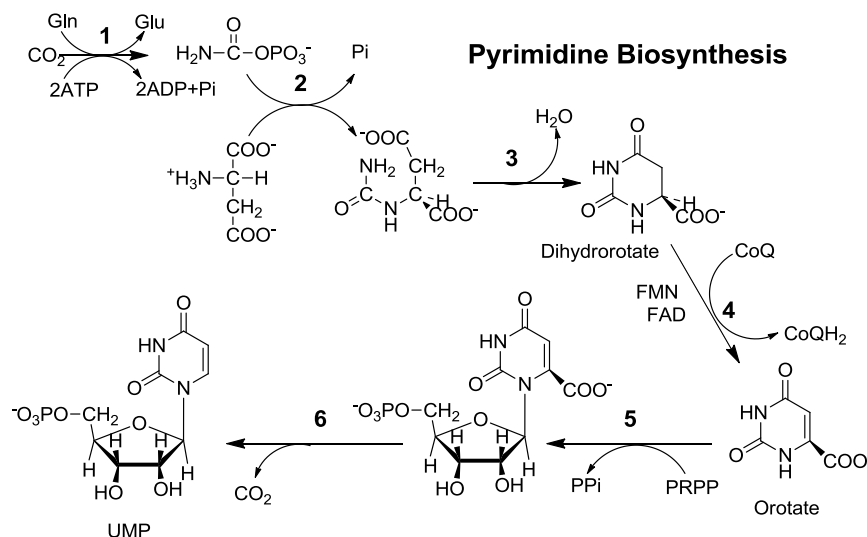
- a. (6 points) If you were studying the biosynthesis of felinine, what compounds would you test as immediate precursors? Explain your choices.

- b. (8 points) Assuming the microbial enzyme that catalyzes the decomposition of felinine to a smelly thiol uses pyridoxal phosphate, show mechanistically (arrow pushing needed) how the reaction likely proceeds. The structure of PLP is given below.



**Part IV: Essay Questions**

- 1 (10 Points) It was 3AM and a group of CHEM-643 students were discussing a homework problem dealing with the catabolic pathway for pyrimidine biosynthesis. Consider a mutant that had 10-fold excess of Enzyme 6 compared to wild type with all other enzymes at wild type levels. What would be the consequences?



Betsy: *I think the concentration of the substrate and product of the enzyme would also increase 10 fold.*

George: *That's not so, the concentration of reaction product would increase, but the substrate would stay about the same.*

Glenn: *If you ask me, you're both wrong. The concentration of substrate and product would change little, but the flux in the pathway would be increased several fold.*

Please help set the students straight on what to expect and the reasons in this example? Feel free to use an illustration.



2. (10 Points) ATP has been described as Nature's dehydrating agent. What does this mean? Explain in words and illustrate with examples.