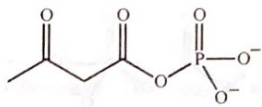


83

OK to use "Ph" anywhere on this exam where appropriate.
 Exceeding the specified word limit on an answer will result in a point deduction for that answer.
 Transition states are not necessary unless the question specifically requires them.
 OK to use the generic B/HB notation anywhere on this exam, except where indicated.

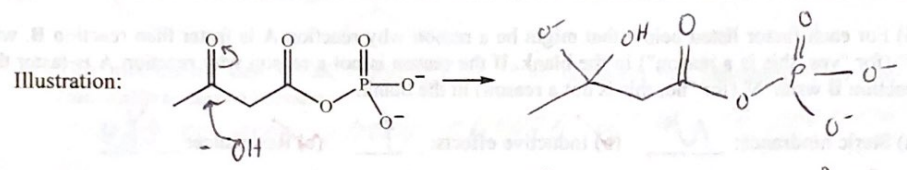
Acyl phosphates such as acetoacetyl phosphate are common intermediates in biochemical reactions involving addition or substitution at a carbonyl group. Questions 1-4 explore the chemistry of these molecules.



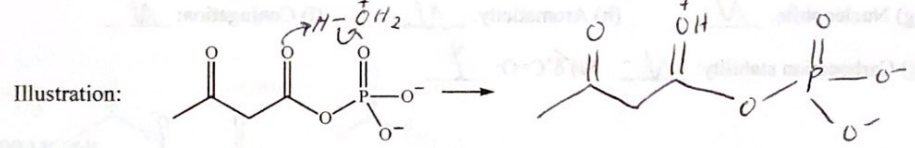
Acetoacetyl phosphate

1. (9) When a carbonyl group is present at the start of a mechanism step, the carbonyl group reacts in one of three common ways (the carbonyl fates). Name these fates, and illustrate each using acetoacetyl phosphate, HO⁻, water and H₃O⁺ as the **only reactants in each case**. If the fate can proceed more than one way, illustrate only the most likely pathway. Include curved arrows. You **may not** use B/HB for this problem.

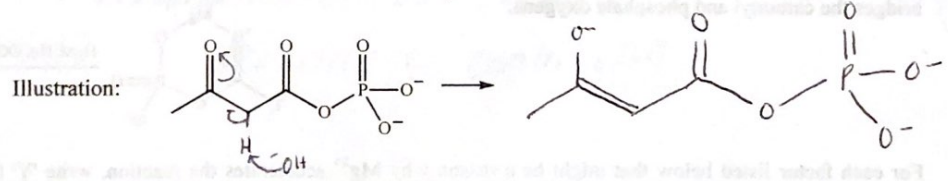
✓ Name of fate #1: accept nucleophile at carbon



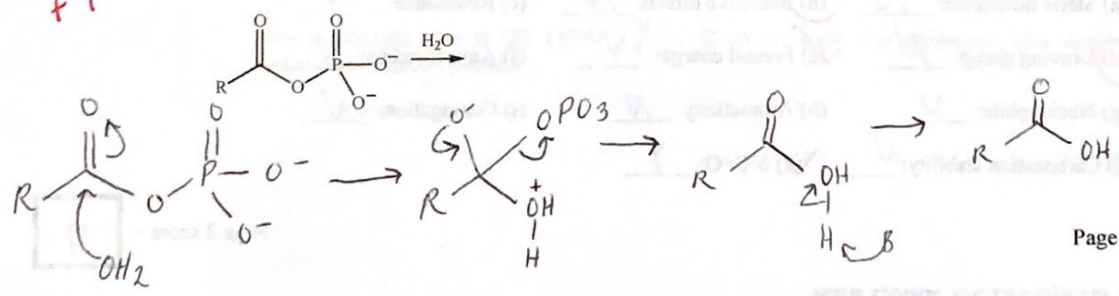
✓ Name of fate #2: accept electrophile (usually a proton) @ oxygen



✓ Name of fate #3: deprotonate, form enolate



2. (9) Acyl phosphates are highly susceptible to aqueous hydrolysis. Write the mechanism and major organic product formed in the following reaction. Draw a box around your major organic product (a product containing one or more carbon atoms).

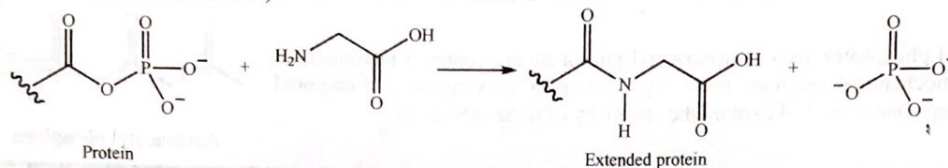


75
92
166
333

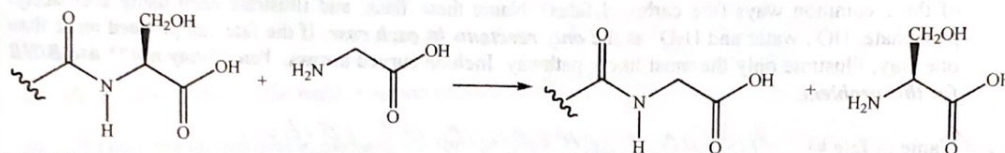
Page 1 score = 18

We can imagine that an acyl phosphate assists the coupling of an amino acid such as glycine ($\text{H}_2\text{NCH}_2\text{COOH}$) to the C-terminus of existing protein chain to form an amide (reaction A). This process is faster than replacement of one of the protein's existing amino acids by a new glycine (reaction B). The questions on this page concern these two reactions.

Reaction A (the faster reaction):



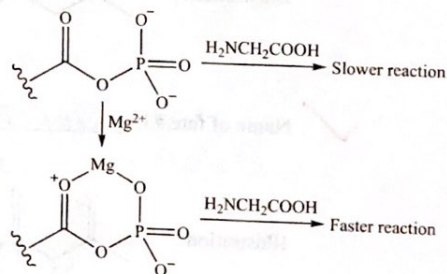
Reaction B (the slower reaction):



3. (6) For each factor listed below that might be a reason why reaction A is faster than reaction B, write 'Y' (for "yes, this is a reason") in the blank. If the reason is not a reason why reaction A is faster than reaction B write 'N' (for "no, this is not a reason") in the blank.

- (a) Steric hindrance: N (b) Inductive effects: Y (c) Resonance: Y
 (d) Leaving group: Y (e) Formal charge: N (f) Atomic radius: N
 (g) Nucleophile: N (h) Aromaticity: N (i) Conjugation: N
 (j) Carbocation stability: N (k) $\delta^+ \text{C}=\text{O}$: Y

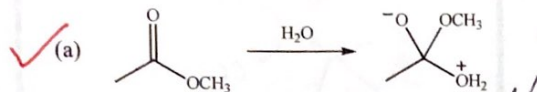
4. (6) Reaction A is further accelerated when a Mg^{2+} ion that bridges the carbonyl and phosphate oxygens:



For each factor listed below that might be a reason why Mg^{2+} accelerates the reaction, write 'Y' (for "yes, this is a reason") in the blank. If the reason is not a reason why Mg^{2+} accelerates write 'N' (for "no, this is not a reason") in the blank.

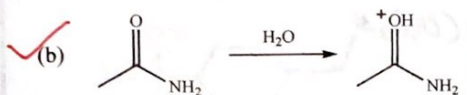
- (a) Steric hindrance: N (b) Inductive effects: N (c) Resonance: N
 (d) Leaving group: N (e) Formal charge: Y (f) Atomic radius: N
 (g) Nucleophile: N (h) Aromaticity: N (i) Conjugation: N
 (j) Carbocation stability: N (k) $\delta^+ \text{C}=\text{O}$: Y

5. (13) For each mechanism step shown below, complete the statement by writing 'Y' (for yes, it is reasonable as shown) in the blank, or 'N' (for no, it is not reasonable as shown, if something other than what is shown is more likely). If you write 'Y' you are done for this mechanism step. If you write 'N' complete the explanation by adding **no more than fifteen words in each case**. Missing curved arrows or missing reaction products are **not** part of the step's improbability or impossibility.



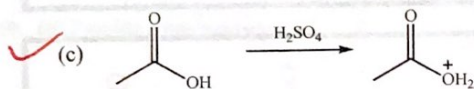
This mechanism step is OK (Y/N) N. If no complete this statement: This step is not reasonable as shown because...

Water not nucleophilic enough to reduce ester



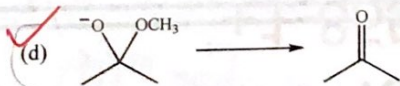
This mechanism step is OK (Y/N) N. If no complete this statement: This step is not reasonable as shown because...

H₂O is not strong enough acid to protonate amide



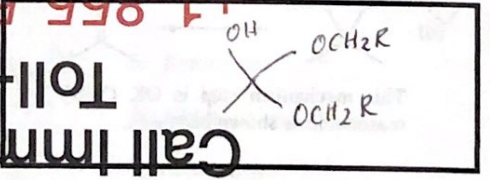
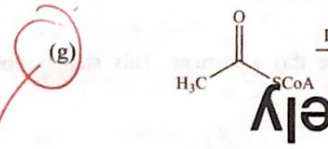
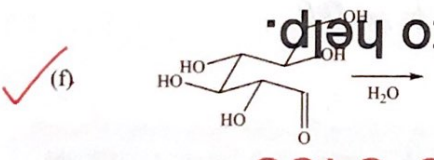
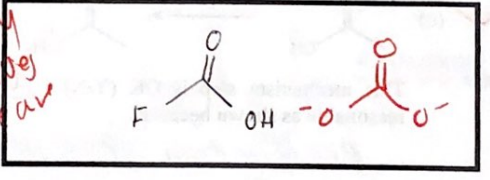
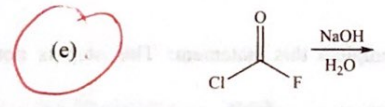
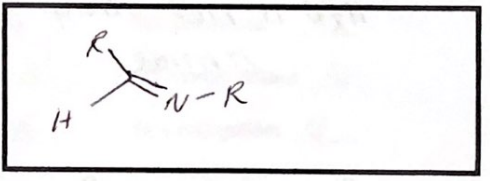
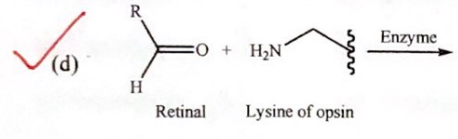
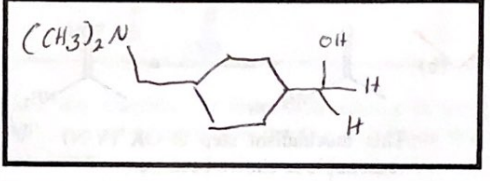
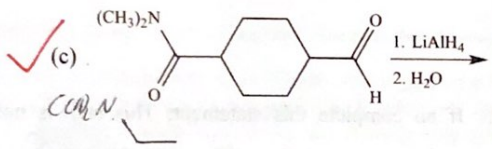
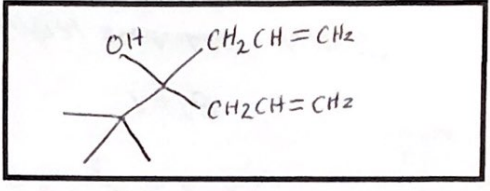
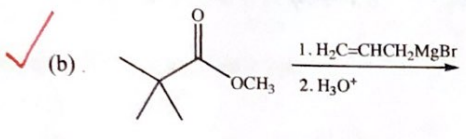
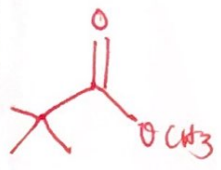
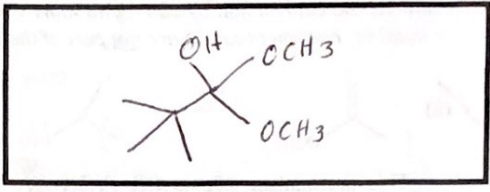
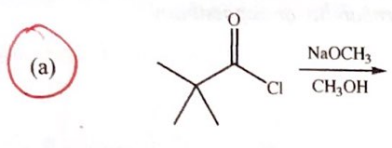
This mechanism step is OK (Y/N) N. If no complete this statement: This step is not reasonable as shown because...

protonation of OH produces less significant resonance contributors



This mechanism step is OK (Y/N) Y. If no complete this statement: This step is not reasonable as shown because...

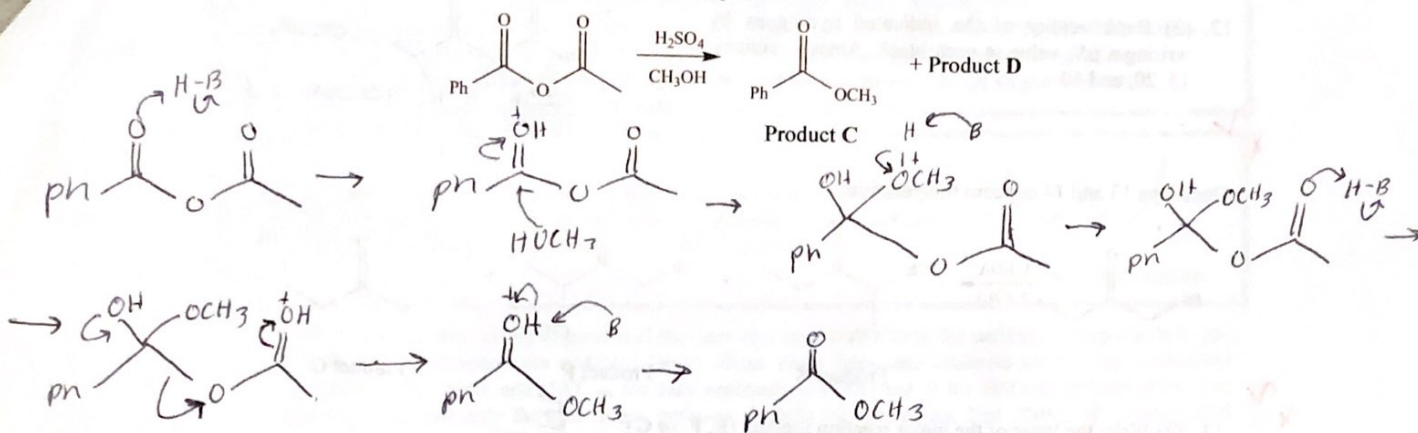
6. (21) Write the organic product(s) in the boxes. If more than one organic product is formed, indicate which product is major. Assume reagents above/below the arrows are in excess. Be sure to indicate stereochemistry if relevant. If no reaction occurs, write "NR." Do not include any mechanism details.



ROH can react w/ ester

7. (1) Write the name of the reaction 6(d) product (not the functional group): imine

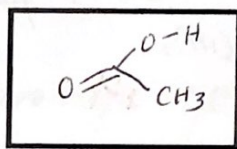
8. (10) Provide a mechanism for the formation of product C:



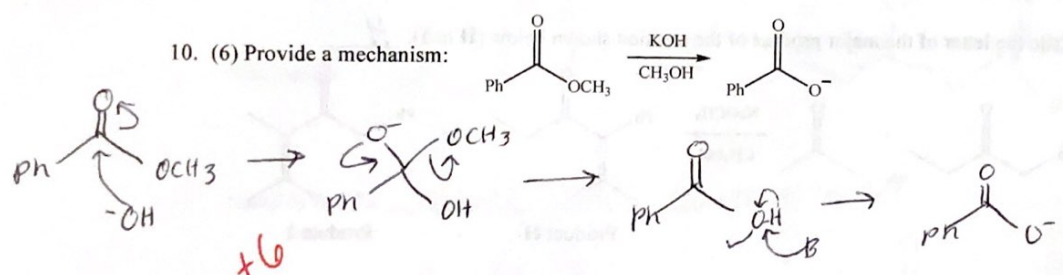
x10

9.

(3) In addition to product C, the reaction in question 8 produces another organic product, product D, which contains *exactly three carbon atoms*. Draw the structure of product D in this box:



10. (6) Provide a mechanism:



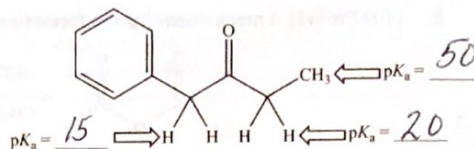
x6

11. (4) Complete this sentence in *fifteen words or less*. Be precise, specific, and concise. The reaction product formed in question 10 is PhCO_2^- and not PhCOOH because...

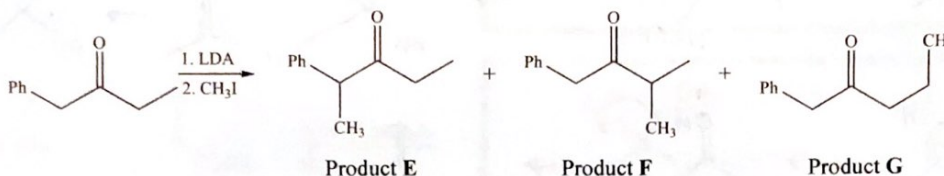
KOH is a strong ~~acid~~ base and deprotonate the carboxylic acid forming carboxylate.

05

12. (2) Rank acidity of the indicated hydrogens by writing a pK_a value in each blank. Answer choices: 15, 20, and 50.

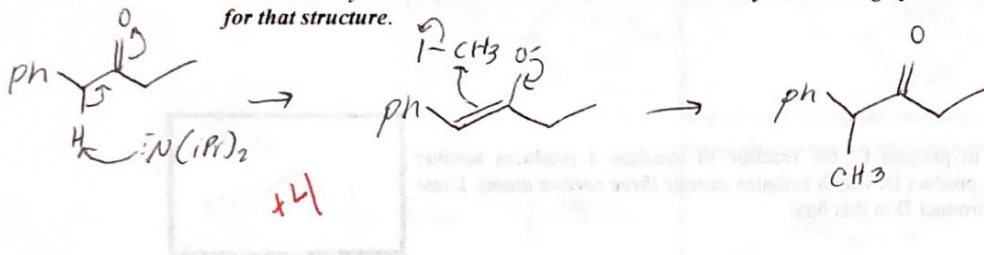


Questions 13 and 14 concern this reaction:

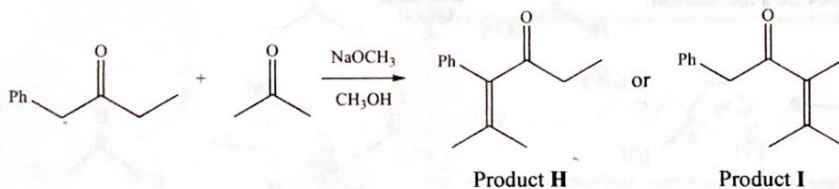


13. (2) Write the letter of the major reaction product (E, F, or G): E

14. (4) Draw the mechanism explaining the formation of your major product choice in question 13. *If any structures in your mechanism have resonance show only the most significant resonance contributor for that structure.*



15. (1) Write the letter of the major product of the reaction shown below (H or I): H



16. (1) Write the name of the reaction shown in question 15. *Be specific and precise.*

Claisen condensation reaction
aldol reaction

17. (1) In the blank write *one* exam problem or answer number, such as 64(q), in which is an example of a carbon atom reduction. If no examples exist write '0'. Problem/answer number: 6c.

18. (1) In the blank write *one* exam problem or answer number, such as 64(q), in which is an example of a carbon atom oxidation. If no examples exist write '0'. Problem/answer number: 6e.