Question No. 1 of 10

Instructions: (1) Read the problem statement and answer choices carefully (2) Work the problems on paper as needed (3) Pick the answer (4) Go back to review the core concept tutorial as needed.

Question

Question 1. Which of the following is ***not*** a physical property of aldehydes and ketones?

(A) Hydrogen bonding exists between molecules in a sample of an aldehyde or ketone.
(B) There are dipole-dipole attractions between molecules.
(C) The hydrogens on the carbons attached to the carbonyl (known as α-hydrogens) are acidic.
(D) Aldehydes and ketones with at least one α-hydrogen exist in equilibrium with their enol forms though in most cases the equilibrium favors the keto product.
(E) The melting points and boiling points of aldehydes and ketones are between alkanes and alcohols.

Feedback

A. Correct!
Hydrogen bonding does not exist between aldehyde or ketone molecules, though the types of compounds can participate in hydrogen bonds with molecules that contain an –OH or –NH.

B. Incorrect!
Due to the differences in electronegativities of the carbon and oxygen, the carbonyl double bond experiences a dipole. Since a dipole exists in the molecule, dipole-dipole attractions would be present between molecules. Go back and review the different physical properties of aldehydes and ketones.

C. Incorrect!
Alpha-hydrogens are acidic (pKa approx. 20). They are acidic due to the electron withdrawing influence of the carbonyl, and, if deprotonated, the resulting anion is resonance stabilized. Go back and review the different physical properties of aldehydes and ketones.

D. Incorrect!
If a ketone or aldehyde has even one α-hydrogen, it can exist in two forms: the enol or keto tautomers. The position of the keto-enol equilibrium favors the keto form in most cases. Go back and review the different physical properties of aldehydes and ketones.

E. Incorrect!
The melting and boiling points of these compounds is between alkanes and alcohols. Go back and review the different physical properties of aldehydes and ketones.

Solution

(1) Recall the different physical properties of aldehydes and ketones that were covered in the tutorial.

In the tutorial, we saw that ketones and aldehydes experience dipole-dipole interactions and could form hydrogen bonds with molecules containing –OH and –NH, though they could not form such bonds with molecules identical to themselves. It was also noted that these compounds tend to be very flammable and have melting and boiling points in a range between alkanes and alcohols. The smaller compounds are typically soluble in water. In this tutorial, we are also introduced to two new concepts: acidic α-hydrogens and enol-keto tautomers. Both are a result of the presence of the carbonyl in aldehydes and ketones.

Alpha-hydrogens are defined as hydrogens bonded to a carbon that is adjacent to a carbonyl. Aldehydes and ketones can have a maximum of two α-carbons, one on each side of the carbonyl carbon. The α-hydrogens have a pKa of approximately 20 making them slightly acidic. They are acidic due in part to the electron withdrawing nature of the adjacent carbonyl. Also, the anion that results from the deprotonation of the α-carbon (called an enolate) is stabilized by resonance.

Also, any ketone or aldehyde that has at least one α-hydrogen can exist in two possible tautomers: the enol or keto forms. The equilibrium usually lies toward the keto tautomer.

(2) Based on the information learned from the tutorial, choose the statement above that is incorrect.

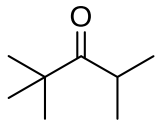
Make sure you read each statement carefully. Statement (A) says that hydrogen bonds exist between molecules in a sample of an aldehyde or ketone. We learned in the tutorial however that while a ketone or aldehyde can participate in hydrogen bonds with a molecule that contains –OH or –NH, there are no hydrogen bonds between molecules of a ketone or aldehyde.

Therefore, the correct answer is (A).

Instructions: (1) Read the problem statement and answer choices carefully (2) Work the problems on paper as needed (3) Pick the answer (4) Go back to review the core concept tutorial as needed.

Question

Question 2. What is the common name for the compound below:



(A) Isopropyl neopentyl ketone
(B) Isopropyl *sec*-butyl ketone
(C) *tert*-butyl isopropyl ketone
(D) 2,2,4-trimethyl-3-pentanone
(E) 2,4,4-trimethyl-3-pentanone

Feedback

A. Incorrect!
While this compound contains a ketone functionality and an isopropyl group, there is no neopentyl group present. Go back and review the common structural motifs and how they are named.

B. Incorrect!
While this compound contains a ketone functionality and an isopropyl group, there is no sec-butyl group present. Go back and review the common structural motifs and how they are named.

C. Correct!
This compound is a ketone with an isopropyl and a tert-butyl group attached to the carbonyl carbon. According to the rules of ketone common nomenclature, the correct name is tert-butyl isopropyl ketone.

D. Incorrect!
Careful! The question asked for the common name of the compound. This possible answer is actually the name of the compound as determined by IUPAC nomenclature.

E. Incorrect!
Careful! The question asked for the common name of the compound. Go back and review the common nomenclature prefixes.

Solution

(1) When asked for common nomenclature, first determine the type of compound the given molecule is.

In this particular case, we have been given a molecule that contains a carbonyl with two alkyl groups attached to it. This molecule must be a ketone.

(2) Recall the common nomenclature for ketones.

In ketone common nomenclature, the ketone is named like the following: alkyl alkyl ketone. The two alkyl groups are listed in alphabetical order (ignoring common prefixes).

(3) Look for common structural motifs.

Look to see if the structure is a straight chain with no branching or if there is branching, determine where the branching occurs. You have approximately five choices to describe the structure of the alkyl group:

(I) n- is used if the chain is straight and the functional group is on one end of the chain.
(II) Iso- is used if the chain contains two methyl groups attached to a –CH with the functional group on the opposite end of the chain.
(III) Sec- is used if the functional group is attached to the secondary carbon of the chain.
(IV) Tert- is used if the functional group is attached to the tertiary carbon of the chain.
(V) Neo- is used if the functional group is attached to a carbon that has 4 other carbons attached to it.

In the above structure, the alkyl portion of the chain to the left of the carbonyl has a total of 4 carbons with the carbonyl carbon attached to the tertiary carbon in this group.. This description is indicative of a tert-butyl group. The alkyl portion of the chain to the right of the carbonyl has a total of 3 carbons. There are two methyl groups attached to a –CH group. This description is indicative of an isopropyl group.

(4) Put the alkyl names alphabetical order followed by the word ketone.

The common name of the molecule is tert-butyl isopropyl ketone.

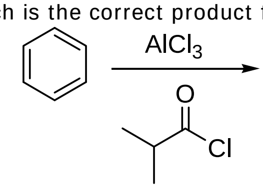
Therefore, the correct answer is (C).

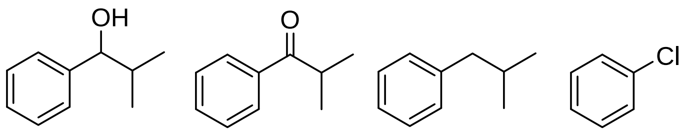
Question No. 3 of 10

Instructions: (1) Read the problem statement and answer choices carefully (2) Work the problems on paper as needed (3) Pick the answer (4) Go back to review the core concept tutorial as needed.

Question

Question 3. Which is the correct product for the reaction below:





I II III IV

(A) I
(B) II
(C) III
(D) IV
(E) No reaction.

Feedback

A. Incorrect!
This alcohol would have only resulted if the carbonyl of the acid halide was somehow reduced. There are no reducing reagents present in the reaction. Go back and review the types of reactions used to form ketones.

B. Correct!
This reaction is the Friedel-Crafts acylation of benzene. The reaction's final product is an aromatic ketone.

C. Incorrect!
This hydrocarbon would have only resulted if the carbonyl of the acid halide was completely reduced somehow. There are no reducing reagents present in the reaction. Go back and review the types of reactions used to form ketones.

D. Incorrect!
This aromatic halide could not have been formed under these conditions. Go back and review the role of the $AlCl_3$ in this reaction.

E. Incorrect!
Benzene does react with acid halides in the presence of Lewis acids like $AlCl_3$. Go back and review the reactions in this tutorial.

Solution

(1) Recall the reactions covered in this tutorial.

The tutorial covered reactions to synthesize aldehydes and ketones, and the reactions aldehydes and ketones undergo.

(2) Determine what kind of reaction is taking place.

To determine what kind of reaction is taking place, you will first need to identify the reactants being used in the reaction. The starting material is benzene (an aromatic). The other reactants are aluminum trichloride and a simple acid halide. You may have already recognized this reaction as the Friedel-Crafts acylation of benzene to form an aromatic ketone. If you did not, go back and review the reactions in this tutorial.

It is not enough to just recognize the type of reaction taking place. You must also understand the mechanism in order to accurately predict the product. Recall that the reaction begins when the acid halide and aluminum trichloride react to form aluminum tetrachloride and an cilium ion. The acyllium ion, which is positively charged, acts an electrophile. The pi electrons of the benzene, acting as the nucleophile, attach the acyllium ion to form an benzenonium intermediate. In the last step, a proton is abstracted from the benzenonium intermediate to re-establishes the ring's aromaticity and form an aromatic ketone.

(3) Predict the product(s).

Based on the known mechanism of this reaction, we can predict the final product will be a ketone.

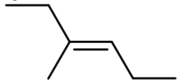
Therefore, the correct answer is (B).

Question No. 4 of 10

Instructions: (1) Read the problem statement and answer choices carefully (2) Work the problems on paper as needed (3) Pick the answer (4) Go back to review the core concept tutorial as needed.

Question

Question 4. If one treats the following alkene with ozone (O_3), what product(s) will be obtained?



(A) Two ketones
(B) Two aldehydes
(C) One aldehyde and one ketone
(D) One ketone and one alcohol
(E) Two carboxylic acids

Feedback

A. Incorrect!
Recall that ozone cleaves the double bond and makes carbonyl compounds from each end. In order to obtain two ketones, there would have to be four alkyl groups attached to the double bond so that each ketone had two alkyl groups attached to its carbonyl carbon. Determine the substitution pattern of the alkene and then review the possible outcomes for the reaction.

B. Incorrect!
Recall that ozone cleaves the double bond and makes carbonyl compounds from each end. In order to obtain two aldehydes, there would have to be two alkyl groups attached to the double bond (one on each end) so that each aldehyde had one alkyl group attached to its carbonyl carbon. Determine the substitution pattern of the alkene and then review the possible outcomes for the reaction.

C. Correct!
Since this alkene is trisubstituted, the products obtained from oxidatively cleaving the double bond will be an aldehyde and a ketone.

D. Incorrect!
While it is possible for one of the products to be a ketone, it is not possible to obtain an alcohol under these conditions. Go back and review the possible products from the oxidative cleavage of alkene by ozone.

E. Incorrect!
Carboxylic acids would not be obtained under these conditions. Determine the substitution pattern of the alkene and then review the possible outcomes for the reaction.

Solution

(1) Recall the reactions covered in this tutorial.

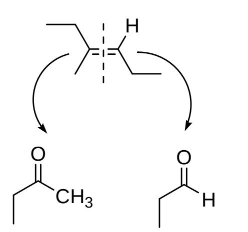
The tutorial covered reactions to synthesize aldehydes and ketones, and the reactions aldehydes and ketones undergo.

(2) Determine what kind of reaction is taking place.

To determine what kind of reaction is taking place, you will first need to identify the reactants being used in the reaction. The starting material is an alkene. The other reactant is ozone, a highly reactive oxidation reagent. You may have already recognized this reaction as the oxidative cleavage of a double bond to form aldehydes and ketones. If you did not, go back and review the reactions in this tutorial.

Recall that in ozonolysis the double bond is cleaved down the center and on the double bond carbons, a carbonyl is formed. Whether one obtains a ketone or aldehyde depends on the substitution pattern of the double bond.

Draw in any hydrogens present on the double bond carbons (these are not usually shown on skeletal structures like the one above). Then draw a line bisecting the double bond. On each carbon of the double bond draw a double bond to an oxygen. This process will help you visualize the correct products for the reaction.



a ketone an aldehyde

(3) Predict the product(s).

Based on what we know about ozonolysis, we can predict that this alkene will yield a ketone and an aldehyde as products.

Therefore, the correct answer is (C).

Question No. 5 of 10

Instructions: (1) Read the problem statement and answer choices carefully (2) Work the problems on paper as needed (3) Pick the answer (4) Go back to review the core concept tutorial as needed.

Question

Question 5. Which statement regarding the reactivity of aldehydes and ketones is ***incorrect***?

(A) In a nucleophilic addition reaction, the reactivity of an aldehyde or a ketone is determined in part by the substituents on the carbonyl (C=O).
(B) Large, bulky groups increase the rate of reaction.
(C) Electron withdrawing substituents on the α-carbon increase the rate of reaction.
(D) In a nucleophilic addition reaction, the nucleophile attacks the partial positive charge on the carbon of the carbonyl.
(E) Electron donating substituents on the α-carbon decrease the rate of reaction.

Feedback

A. Incorrect!
Electron withdrawing substituents and sterically hindered substituents can impact the rate of reaction of an aldehyde or ketone in a nucleophilic addition reaction. Go back and review the tutorial section on the reactivity of aldehydes and ketones.

B. Correct!
Large, bulky groups will actually decrease the rate of reaction of an aldehyde or ketone in a nucleophilic addition reaction. The large groups increase steric hindrance around the electrophile, the carbon of the carbonyl, so that the incoming nucleophile has difficulty reaching it.

C. Incorrect!
The addition of electron withdrawing substituents on the α-carbon increases the rate of reaction by increasing the electrophilicity of the adjacent carbonyl carbon. Review the tutorial section on the reactivity of aldehydes and ketones.

D. Incorrect!
Carbonyl carbons do possess a partial positive charge. The difference in electronegativity between carbon and oxygen results in the carbon becoming somewhat electrophilic. Since the carbon is electron poor, it is susceptible to nucleophilic attack.

E. Incorrect!
Electron donating substituents pump electron density towards the carbon of the carbonyl thereby making it less reactive in interactions with a nucleophile. Review the tutorial section on the reactivity of aldehydes and ketones.

Solution

(1) Recall the tutorial section on the reactivity of aldehydes and ketones.

In this section, we learned in a nucleophilic addition reaction to a ketone or aldehyde, that the nucleophile attacks the partial positive charge of the carbonyl carbon (The difference in electronegativity between carbon and oxygen results in the carbon becoming somewhat electrophilic. Since the carbon is electron poor, it is susceptible to nucleophilic attack.). The reactivity of the ketone or aldehyde is determined in part by the substituents attached to the carbonyl carbon. The addition of electron withdrawing substituents on the α-carbon increases the rate of reaction by increasing the electrophilicity of the adjacent carbonyl carbon. The addition of electron donating groups has the opposite effect. However, large, bulky groups will actually decrease the rate of reaction of an aldehyde or ketone in a nucleophilic addition reaction (The large groups increase steric hindrance around the electrophile, the carbon of the carbonyl, so that the incoming nucleophile has difficulty reaching it).

(2) Read each statement carefully and determine which statement is incorrect.

Based on the information in the tutorial, we can determine that statement (B) is incorrect as large bulky groups will decrease the rate of reaction.

Therefore, the correct answer is (B).

Instructions: (1) Read the problem statement and answer choices carefully (2) Work the problems on paper as needed (3) Pick the answer (4) Go back to review the core concept tutorial as needed.

Question

Question 6. If one reacts a ketone with hydrogen and Raney nickel, what type of product will be obtained?

(A) alkane
(B) primary alcohol
(C) secondary alcohol
(D) tertiary alcohol
(E) ether

Feedback

A. Incorrect!
An alkane could not be obtained under these conditions. Go back and review the product(s) obtained when a ketone is reduced using Raney nickel and hydrogen.

B. Incorrect!
A primary alcohol would not be obtained in this reaction. Recall the structure of a ketone. How many alkyl groups are present in a ketone? If you then reduced the ketone with Raney nickel, how would you classify the product?

C. Correct!
The carbon-oxygen double bond is reduced to the secondary alcohol using Raney nickel and hydrogen. (Aldehydes are reduced to primary alcohols.)

D. Incorrect!
A tertiary alcohol would not be obtained in this reaction. Recall the structure of a ketone. How many alkyl groups are present in a ketone? If you then reduced the ketone with Raney nickel, how would you classify the product?

E. Incorrect!
An ether would not be obtained in this reaction. Go back and review the reductions of carbonyl compounds.

Solution

(1) Recall the reactions covered in this tutorial.

The tutorial covered reactions to synthesize aldehydes and ketones, and the reactions aldehydes and ketones undergo.

(2) Determine what kind of reaction is taking place.

To determine what kind of reaction is taking place, you will first need to identify the reactants being used in the reaction. The starting material is a ketone. The other reactants are Raney nickel and hydrogen. You may have already recognized this reaction as the reduction of a ketone using Raney nickel and hydrogen. If you did not, go back and review the reactions in this tutorial.

Recall that in the reduction of a ketone using a metal and hydrogen gas, the carbon-oxygen double bond is reduced to a single bond yielding an alcohol as the final product.

(3) Predict the product(s).

Based on what we know about the reduction of a ketone using Raney nickel, we can predict the final product should be an alcohol. However, there are three possible choices listing an alcohol as the final product. Recall the definition of a ketone: a carbonyl with two alkyl groups attached. Now, recall the classification system for alcohols (0^0, 1^0, 2^0, 3^0, or phenol). If a ketone (with two alkyl groups) is reduced to an alcohol, one would expect the alcohol would still have the same two alkyl groups. One could then classify the alcohol formed as a secondary alcohol.

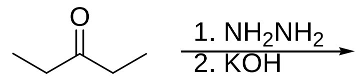
Therefore, the correct answer is (C).

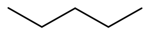
Question No. 7 of 10

Instructions: (1) Read the problem statement and answer choices carefully (2) Work the problems on paper as needed (3) Pick the answer (4) Go back to review the core concept tutorial as needed.

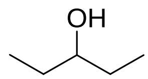
Question

Question 7. What is the correct product for the reaction below:

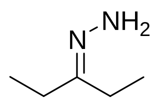




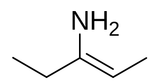
I



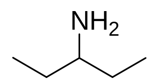
II



III



IV



V

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

Feedback

A. Correct!
These conditions, called the Wolff-Kishner reaction, will reduce the carbonyl compound to an alkane.

B. Incorrect!
While these conditions do initiate a reduction of the carbon-oxygen double bond, an alcohol will not be the final product. Go back and review the Wolff-Kishner reaction.

C. Incorrect!
While a probable intermediate of this reaction, a hydrazone is not the final product. Go back and review the methods for reducing ketones and aldehydes under basic conditions.

D. Incorrect!
A vinyl amine will not be the product of this reaction. Go back and review the methods for reducing ketones and aldehydes under basic conditions.

E. Incorrect!
A primary amine would not be obtained under these conditions. Go back and review the methods for reducing ketones and aldehydes under basic conditions.

Solution

(1) Recall the reactions covered in this tutorial.

The tutorial covered reactions to synthesize aldehydes and ketones, and the reactions aldehydes and ketones undergo.

(2) Determine what kind of reaction is taking place.

To determine what kind of reaction is taking place, you will first need to identify the reactants being used in the reaction. The starting material is a ketone. The other reactants are hydrazine and potassium hydroxide. You may have already recognized this reaction as the Wolff-Kishner reduction of a ketone. If you did not, go back and review the reactions in this tutorial.

Recall that in this reaction, a carbonyl compound is completely reduced to the alkane under basic conditions.

(3) Predict the product(s).

We would expect 3-pentanone to be reduced to pentane.

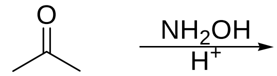
Therefore, the correct answer is (A).

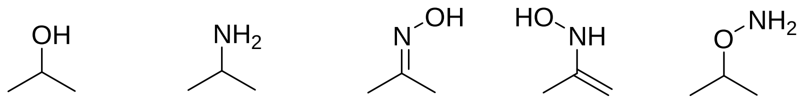
Question No. 8 of 10

Instructions: (1) Read the problem statement and answer choices carefully (2) Work the problems on paper as needed (3) Pick the answer (4) Go back to review the core concept tutorial as needed.

Question

Question 8. What is the correct product for the reaction below:





I II III IV V

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

Feedback

A. Incorrect!
An alcohol could only be obtained if the carbonyl of the starting ketone was reduced. These conditions would not accomplish such a reduction. Go back and review the different reactions that produce imine derivatives.

B. Incorrect!
An amine could not be obtained as a product under these conditions. Go back and review the different reactions that produce imine derivatives.

C. Correct!
An oxime, a derivative of an imine, is the product of the reaction between a ketone and hydroxylamine under acidic conditions.

D. Incorrect!
A vinyl hydroxylamine would not be obtained as a product under these conditions. Go back and review the different reactions that produce imine derivatives.

E. Incorrect!
This alkoxyamine would not be obtained as a product under these conditions. Go back and review the different reactions that produce imine derivatives.

Solution

(1) Recall the reactions covered in this tutorial.

The tutorial covered reactions to synthesize aldehydes and ketones, and the reactions aldehydes and ketones undergo.

(2) Determine what kind of reaction is taking place.

To determine what kind of reaction is taking place, you will first need to identify the reactants being used in the reaction. The starting material is a ketone. The other reactants are hydroxylamine and an acid. You may have already recognized this reaction as the formation of an oxime from a ketone. If you did not, go back and review the reactions in this tutorial.

Recall that an oxime is an imine derivative and is formed through a similar mechanism from the reaction of hydroxylamine with a ketone or aldehyde. An oxime is a functional group containing a carbon that is doubly bonded to a nitrogen that is also bonded to a hydroxyl group.

(3) Predict the product(s).

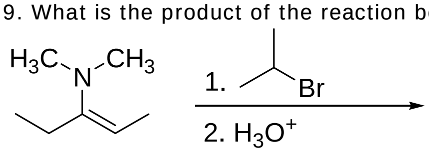
We would expect the final product to be an oxime.

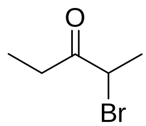
Therefore, the correct answer is (C).

Question No. 9 of 10

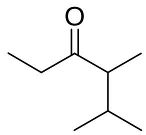
Instructions: (1) Read the problem statement and answer choices carefully (2) Work the problems on paper as needed (3) Pick the answer (4) Go back to review the core concept tutorial as needed.

Question 9. What is the product of the reaction below:

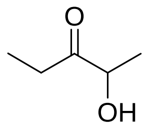




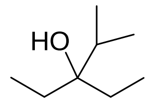
I



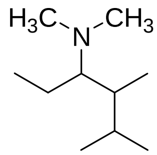
II



III



IV



V

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

A. Incorrect!
Close! The enamime acts as the nucleophile and the electrophile. But what portion of the alkyl halide is most electrophilic? Consider the atoms electronegativity in answer that question.

B. Correct!
The β-carbon of the enamine acts as the nucleophile and attacks the alkyl halide. This attack forms a bond between the β-carbon of the enamine and the halogenated carbon of the halide. The intermediate iminium ion is attacked by water and the amine group is displaced. The final product is a ketone.

C. Incorrect!
An α-hydroxyketone will not form under these conditions. Go back and review the mechanism for alkylating an enamine.

D. Incorrect!
This alcohol will not form under these conditions. Go back and review the mechanism for alkylating an enamine.

E. Incorrect!
This amine would not be obtained under these conditions. Go back and review the mechanism for alkylating an enamine.

(1) Recall the reactions covered in this tutorial.

The tutorial covered reactions to synthesize aldehydes and ketones, and the reactions aldehydes and ketones undergo.

(2) Determine what kind of reaction is taking place.

To determine what kind of reaction is taking place, you will first need to identify the reactants being used in the reaction. The starting material is an enamime which possesses a nucleophilic β-carbon. The other reactants are isopropyl bromide and aqueous acid. You may have already recognized this reaction as the alkylation of an enamine. If you did not, go back and review the reactions in this tutorial.

Recall that an enamine is formed from the reaction of an aldehyde or ketone with a secondary amine. Since the enamine contains a nucleophilic β-carbon, it will attack electrophiles like acid halides, primary alkyl halides and secondary alkyl halides. In this case, the electrophile is the secondary alkyl halide isopropyl bromide. A new bond is formed between the β-carbon and the carbon bonded to the bromine. The halogen is displaced in the process. The intermediate formed after alkylation of the β-carbon, called iminium ion ($R_2C{=}N^+R_2$), then is attacked by a molecule of water. After a series of proton transfers, the amine group ($-NR_2$) is displaced and a carbon-oxygen double bond is formed yielding an alpha-alkylated ketone or aldehyde as the final product.

(3) Predict the product(s).

We would expect the final product to be a ketone with an isopropyl group attached at an α-carbon.

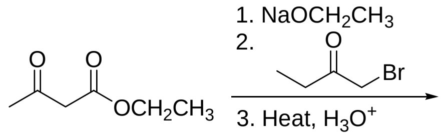
Therefore, the correct answer is (B).

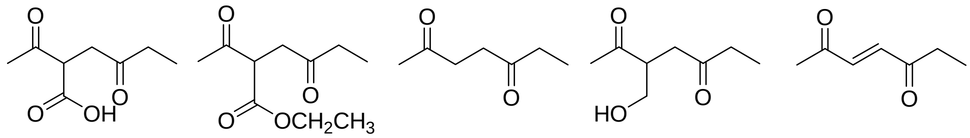
Question No. 10 of 10

Instructions: (1) Read the problem statement and answer choices carefully (2) Work the problems on paper as needed (3) Pick the answer (4) Go back to review the core concept tutorial as needed.

Question

Question 10. What is the final product obtained for the reaction below:





I II III IV V

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

Feedback

A. Incorrect!
While this carboxylic acid may be an intermediate of this reaction, it is not the final product. Go back and review synthesis using the acetoacetic ester.

B. Incorrect!
While this ester may be an intermediate of this reaction, it is not the final product. Go back and review synthesis using the acetoacetic ester.

C. Correct!
This diketone is the final product of this three step reaction. The enolate ion is formed in the first step. In the second step, the nucleophilic enolate attacks the electrophile. In the last step, the ester is hydrolyzed to the carboxylic acid. The resulting β-ketoacid undergoes decarboxylation to give the final product.

D. Incorrect!
This alcohol can not be formed under these conditions. Go back and review synthesis using the acetoacetic ester.

E. Incorrect!
This unsaturated diketone would not be obtained under these conditions. Go back and review the acetoacetic ester synthesis.

Solution

(1) Recall the reactions covered in this tutorial.

The tutorial covered reactions to synthesize aldehydes and ketones, and the reactions aldehydes and ketones undergo.

(2) Determine what kind of reaction is taking place.

To determine what kind of reaction is taking place, you will first need to identify the reactants being used in the reaction. The starting material is β-ketoester which contains highly acidic α-hydrogens. The other reactants are (in order of steps listed) sodium ethoxide, a strong base, 1-bromo-2-butanone, and aqueous acid. You may have already recognized this reaction as the alkylation of the β-ketoester followed by hydrolysis of the ester and decarboxylation. If you did not, go back and review the reactions in this tutorial.

Recall that a β-ketoester is an ideal starting material for making new carbon-carbon bonds. The α-hydrogens are acidic and when deprotonated, form a nucleophilic enolate ion. Once the enolate ion is formed, it can be combined with a variety of electrophiles: primary and secondary halides, α-haloketones, and α-haloesters. In this case, the enolate formed in step one is combined with an α-haloketone. The enolate attacks the α-carbon displacing the halide. At this point in the mechanism, the reaction intermediate looks like II. However, when exposed to heat and aqueous acid, the ester hydrolyzes to the carboxylic acid and then the acid decarboxylates. This last step, in this case, yields a diketone as the final product.

(3) Predict the product(s).

We expect a simple diketone as the final product.

Therefore, the correct answer is (C).

