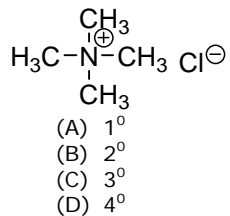


Question No. 1 of 10

Instructions: (1) Read the problem 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 #01

Question 1. What is the classification of this amine?



Feedback on Each Answer Choice

- A. Incorrect!
Remember that amines are classified by the number of carbons directly attached to the nitrogen. How many carbons are on the nitrogen above?
- B. Incorrect!
Remember that amines are classified by the number of carbons directly attached to the nitrogen. How many carbons are on the nitrogen above?
- C. Incorrect!
Remember that amines are classified by the number of carbons directly attached to the nitrogen. How many carbons are on the nitrogen above?
- D. Correct!
This amine has four carbons attached to its nitrogen. Thus, it is a quaternary amine.

Solution

- (1) Recall the classification system for amines.
- Amines are classified by the number of carbons directly attached to the nitrogen. There are 4 flavors: primary (1 carbon on amine), secondary (2 carbons on amine), tertiary (3 carbons on amine), and quaternary (4 carbons on amine).
- (2) Look at the structure of the amine and count the number of carbons attached.
- There are 4 carbons attached to the nitrogen on the amine so it must be quaternary.
- Therefore, the correct answer is (D).

Question No. 2 of 10

Instructions: (1) Read the problem 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 #02	<p>Question 2. What is the hybridization of the nitrogen in a secondary amine?</p> <p>(A) sp (B) sp^2 (C) sp^3 (D) s orbital only</p>
Feedback on Each Answer Choice	<p>A. Incorrect! A hybridization of sp indicates a linear shape. A secondary amine does not have a linear shape. Go back and review the shape of amines.</p> <p>B. Incorrect! A hybridization of sp^2 indicates an atom has three groups around it. How many groups (including lone pairs) are around the nitrogen of a secondary amine?</p> <p>C. Correct! A secondary amine has one hydrogen and two alkyl groups attached to its nitrogen. There is also a lone pair present on the nitrogen that must be account for since it affects the molecule's shape. The nitrogen has four groups around it in essence so it is sp^3 hybridized.</p> <p>D. Incorrect! S orbitals by themselves are not considered hybrid orbitals. Nitrogen will combine its available s and p orbitals into hybrid orbitals in order to make bonds. Go back and review the shape of amines.</p>
Solution	<p>(1) Recall the details of the structure of amines.</p> <p>Primary, secondary, and tertiary amines consist of nitrogen with three sigma bonds to other groups/atoms. There is also a lone pair on the nitrogen. This means there are four groups of electrons associated with the nitrogen. The hybridization for primary, secondary, and tertiary amines is sp^3. Mutual repulsion of these groups leads to a tetrahedral like arrangement though the bond angle is somewhat compressed due to the presence of the lone pair.</p> <p>(2) Read each choice and choose the correct one.</p> <p>Therefore, the correct answer is (C).</p>

Question No. 3 of 10

Instructions: (1) Read the problem 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.

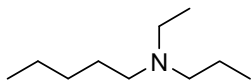
Question #03	<p>Question 3. Which statement below regarding the basicity of amines is incorrect?</p> <p>(A) All amines are weak bases and their aqueous solutions are basic. (B) Aliphatic amines are slightly weaker bases than ammonia. (C) Aromatic amines are slightly weaker bases than ammonia. (D) Electron donating groups attached to the nitrogen increase the basicity of the amine.</p>
Feedback on Each Answer Choice	<p>A. Incorrect! Amines can use their lone pair as a proton acceptor (Bronsted-Lowry base definition) so they are weak bases and any aqueous solution containing them will be basic. Go back and review the properties of amines.</p>
	<p>B. Correct! Aliphatic amines are slightly stronger bases than ammonia due to the inductive electron donation of the alkyl groups on the nitrogen.</p>
	<p>C. Incorrect! Aromatic amines are slightly weaker bases than ammonia because the lone pair of the nitrogen is delocalized by resonance into the aromatic ring. Go back and review the properties of amines.</p>
	<p>D. Incorrect! Electron donating groups attached to the nitrogen will increase the basicity of the amine. Go back and review the properties of amines.</p>
Solution	<p>(1) Recall the acid-base properties of amines.</p> <p>Amines can act as proton acceptors (Bronsted-Lowry definition of base) since they have a lone pair of electrons. They are weak bases and any aqueous solution containing them will be weakly basic. Aliphatic amines are typically slightly stronger bases than ammonia due to the inductive electron donation of the alkyl groups on the nitrogen. On the other hand, aromatic amines are slightly weaker bases than ammonia because the lone pair of electrons on the nitrogen can be delocalized into the aromatic ring. Electron donating groups attached to the nitrogen will increase the basicity of the amine while electron withdrawing groups will decrease the basicity of the amine.</p> <p>(2) Read each statement carefully and determine which one is incorrect.</p> <p>Therefore, the correct answer is (B).</p>

Question No. 4 of 10

Instructions: (1) Read the problem 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 #04

Question 4. What is the correct IUPAC name for the compound shown?



- (A) N-ethyl-N-propyl-1-pentanamine
- (B) N-ethyl-N-pentyl-1-propanamine
- (C) N-pentyl-N-propyl-1-ethanamine
- (D) N, N-dipropyl-1-pentanamine

Feedback on Each Answer Choice

A. Correct!

This name correctly reflects the presence of two alkyl groups, an ethyl and a propyl group, on the nitrogen. The longest chain on the nitrogen is 5 carbons long so the parent is pentanamine.

B. Incorrect!

Recall that the longest chain present on the nitrogen should be the parent compound. Which chain is the longest? . Go back and review the IUPAC rules for naming amines.

C. Incorrect!

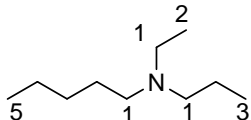
Recall that the longest chain present on the nitrogen should be the parent compound. Which chain is the longest? . Go back and review the IUPAC rules for naming amines.

D. Incorrect!

Careful! Make sure you correctly number the carbons in each chain on the nitrogen to ensure you use the proper alkyl and numerical prefixes. Go back and review the IUPAC rules for naming amines.

Solution

(1) Find the longest carbon chain and the main functional group in the molecule to determine the parent.



The longest carbon chain is comprised of five carbons. The molecule is an amine (the alcohol suffix is – anamine) so the parent's name is pentanamine.

When an amine is present, the chain is numbered so that C-N bond has the lowest possible number. The location number of the amine group is placed in front of the parent: 1-pentanamine.

(2) Determine the substituents and their correct location numbers.

In determining the names of the substituents, make a list of the substituents present in the molecule. There is an ethyl group and propyl group attached to the nitrogen.

Since the other substituents are all bonded to the nitrogen, the letter N serves as their location number. N-ethyl, N-propyl.

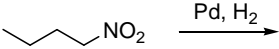
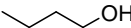

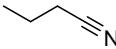
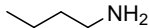
(3) Put the substituents in alphabetical order (ignoring any numerical prefixes) and place in front of the parent name.

N-ethyl-N-propyl-1-pentanamide.

Therefore, the correct answer is (A).

Question No. 5 of 10

Instructions: (1) Read the problem 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 #05	<p>Question 5. What is the product of the following reaction?</p> <div style="text-align: center;"></div> <div style="display: flex; justify-content: space-around; align-items: flex-start;"><div style="text-align: center;"> I</div><div style="text-align: center;"> II</div><div style="text-align: center;"> III</div><div style="text-align: center;"> IV</div></div> <p>(A) I (B) II (C) III (D) IV</p>
Feedback on Each Answer Choice	<p>A. Incorrect! An alcohol will not be obtained under these conditions. Go back and review the reactions in the tutorial. What is the hydrogen and palladium doing to the nitro group?</p>
	<p>B. Incorrect! An alkane will not be obtained under these conditions. Go back and review the reactions in the tutorial. What is the hydrogen and palladium doing to the nitro group?</p>
	<p>C. Incorrect! A nitrile will not be obtained under these conditions. The addition of hydrogen is what type of reaction? Go back and review the role of a metal and hydrogen gas in this reaction.</p>
	<p>D. Correct! The palladium and hydrogen gas reduce the nitro group to an amine group.</p>
Solution	<p>(1) Recall the reactions covered in this tutorial.</p> <p>The tutorial covered reactions to synthesize amines and the reactions amines undergo.</p> <p>(2) Determine what kind of reaction is taking place.</p> <p>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 aliphatic nitro compound. The other reactants are palladium metal and hydrogen gas. You may have already recognized this reaction as the reduction of a nitro group to form an amine. If you did not, go back and review the reactions in this tutorial.</p> <p>(3) Predict the product(s).</p> <p>Based on what we know about the reaction, we can predict that the product should be an amine. There is only one amine listed in the choices above.</p> <p>Therefore, the correct answer is (D).</p>

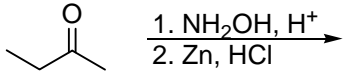
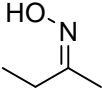

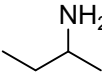
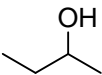
Question No. 6 of 10

Instructions: (1) Read the problem 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.

<p>Question #06</p>	<p>Question 6. What is the product of the following reaction?</p> <div style="text-align: center;"> </div> <div style="display: flex; justify-content: space-around; align-items: flex-start; margin-top: 10px;"> <div style="text-align: center;"> <p>I</p> </div> <div style="text-align: center;"> <p>II</p> </div> <div style="text-align: center;"> <p>III</p> </div> <div style="text-align: center;"> <p>IV</p> </div> </div> <p>(A) I (B) II (C) III (D) IV</p>
<p>Feedback on Each Answer Choice</p>	<p>A. Incorrect! An alkane will not be obtained under these conditions. Go back and review the types of reactions amines undergo.</p>
	<p>B. Correct! Since there are two equivalents of the bromide present, the halide can add twice to the molecule of ammonia.</p>
	<p>C. Incorrect! While this amine is an intermediate of this reaction, it is not the final product. As long as there is an alkyl halide present and a hydrogen to be deprotonated on the nitrogen, the addition can continue. Go back and review the mechanism of this reaction.</p>
	<p>D. Incorrect! While this amine salt is an intermediate of this reaction, it is not the final product. Go back and review the mechanism of this reaction.</p>
<p>Solution</p>	<p>(1) Recall the reactions covered in this tutorial.</p> <p>The tutorial covered reactions to synthesize amines and the reactions amines undergo.</p> <p>(2) Determine what kind of reaction is taking place.</p> <p>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 ammonia (the simplest amine possible). The other reactant is propyl bromide (2 equivalents of which are present). You may have already recognized this as the reaction of ammonia with an alkyl halide to form a more substituted amine. If you did not, go back and review the reactions in this tutorial.</p> <p>In this reaction, the lone pair on the nitrogen attacks the electrophilic carbon of the propyl bromide (the carbon directly bonded to the halogen). Propyl ammonium bromide that results is then deprotonated by the bromide to give 1-propanamine. However, since a second equivalent of the halide is present and a hydrogen is left on the nitrogen (to be deprotonated later), the addition can occur again. The final product will be the secondary amine dipropyl amine.</p> <p>(3) Predict the product(s).</p> <p>The final product will be the secondary amine dipropyl amine.</p> <p>Therefore, the correct answer is (B).</p>

Question No. 7 of 10

Instructions: (1) Read the problem 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 #07	<p>Question 7. What is the product of the reaction shown?</p> <div style="text-align: center;"></div> <div style="display: flex; justify-content: space-around; align-items: flex-start;"><div style="text-align: center;"> I</div><div style="text-align: center;"> II</div><div style="text-align: center;"> III</div><div style="text-align: center;"> IV</div></div> <p>(A) I (B) II (C) III (D) IV</p>
Feedback on Each Answer Choice	<p>A. Incorrect! While this oxime is an intermediate of this series of steps, it is not the final product. Go back and review the mechanism of reductive amination.</p> <p>B. Incorrect! An alkane would not be obtained under these conditions. Go back and review the process of reductive amination.</p> <p>C. Correct! Initially, the oxime is formed. In the second step, the zinc and hydrochloric acid will reduce the oxime to the amine in a process called reductive amination.</p> <p>D. Incorrect! An alcohol would not be obtained under these conditions. Go back and review the process of reductive amination.</p>
Solution	<p>(1) Recall the reactions covered in this tutorial.</p> <p>The tutorial covered reactions to synthesize amines and the reactions amines undergo.</p> <p>(2) Determine what kind of reaction is taking place.</p> <p>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 catalytic acid in the first step while in the second step, the reagents are zinc metal and hydrochloric acid. You may have already recognized this as two step series to form an amine. In the first step, an oxime is formed. In the second step, the oxime is reduced to form the final product—an amine. If you did not, go back and review the reactions in this tutorial.</p> <p>We have seen each of these reactions in other contexts in previous tutorials. Here, the two steps are combined to give a totally different outcome. In the first step, the hydroxylamine attacks the carbonyl. Water is displaced and a carbon-nitrogen double bond is formed. This intermediate is called an oxime. In the second step, zinc metal and hydrochloric acid reduce the oxime to an amine.</p> <p>(3) Predict the product(s).</p> <p>The final product will be an amine. The only amine listed above is III.</p> <p>Therefore, the correct answer is (C).</p>

Question No. 8 of 10

Instructions: (1) Read the problem 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 #08

Question 8. What is the product from the reaction an acid chloride and an amine?

- (A) aldehyde
- (B) amide
- (C) nitrile
- (D) quaternary ammonium salt

Feedback on Each Answer Choice

A. Incorrect!

An aldehyde will not be obtained under these circumstances. It might also help to draw a generic acid chloride and amine to help you visualize the reaction. Go back and review the reactions amines undergo.

B. Correct!

An acid chloride and an amine will react to form an amide.

C. Incorrect!

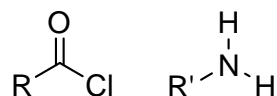
A nitrile will not be obtained under these circumstances. It might also help to draw a generic acid chloride and amine to help you visualize the reaction. Go back and review the reactions amines undergo.

D. Incorrect!

A quaternary ammonium salt will not be obtained under these circumstances. It might also help to draw a generic acid chloride and amine to help you visualize the reaction. Go back and review the reactions amines undergo.

Solution

(1) Recall the structure of an acid chloride (on the left) and an amine (on the right).



(2) Consider the different ways these compounds could react if mixed together.

From what we learned in the tutorial, we know that acid halides react as electrophiles and amines react as nucleophiles. If these were mixed together, we would assume the roles would be the same here. The amine will attack the carbonyl of the anhydride forming a new bond between the carbonyl carbon and the nitrogen. The chloride atom becomes a leaving group which allows the carbon-oxygen double bond of the carbonyl attacked to reform.

(3) Predict the products.

Based on this mechanism, we would expect an amide to be the final product of the reaction.

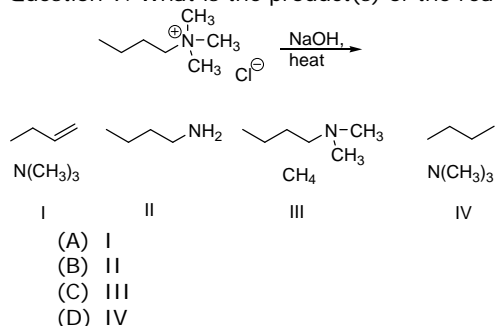
Therefore the correct answer is (B).

Question No. 9 of 10

Instructions: (1) Read the problem 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 #09

Question 9. What is the product(s) of the reaction shown?



Feedback on Each Answer Choice

A. Correct!

The products of the Hofmann elimination are an alkene and a tertiary amine.

B. Incorrect!

This amine will not be obtained under these conditions. Go back and review the mechanism for the Hofmann elimination.

C. Incorrect!

This amine and methane will not be obtained under these conditions. Go back and review the mechanism for the Hofmann elimination.

D. Incorrect!

This alkane and amine will not be obtained under these conditions. Go back and review the mechanism for the Hofmann elimination.

Solution

(1) Recall the reactions covered in this tutorial.

The tutorial covered reactions to synthesize amines and the reactions amines undergo.

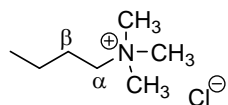
(2) Determine what kind of reaction is taking place.

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 quaternary ammonium salt. The other reactants are sodium hydroxide and heat. You may have already recognized this reaction as the Hofmann elimination that forms an alkene as the final product. If you did not, go back and review the reactions in this tutorial.

When treated with a strong base and heat, a quaternary ammonium halide will undergo β -elimination. The reaction proceeds via an E2 mechanism to yield the least substituted alkene product. In the elimination, the rest of the amine serves as the leaving group so for every alkene molecule made, a molecule of a tertiary amine is also made.

(3) Predict the product(s).

The final products will be an alkene and a tertiary amine. What about the substitution of the alkene produced? The Hofmann elimination typically yields the least substituted alkene. You only have to worry about this if there is more than one β carbon to deprotonate in the course of the reaction. In the given starting material, however, there is only one β carbon so we don't have to consider it in this case.

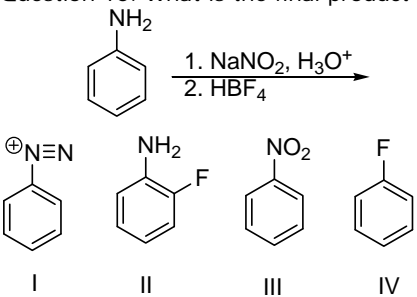


The correct alkene and amine must be I.

Therefore, the correct answer is (A).

Question No. 10 of 10

Instructions: (1) Read the problem 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.

<p>Question #10</p>	<p>Question 10. What is the final product of this reaction?</p> <div style="text-align: center;">  </div> <p>I II III IV</p> <p>(A) I (B) II (C) III (D) IV</p>
<p>Feedback on Each Answer Choice</p>	<p>A. Incorrect! While an intermediate of the reaction, this arenediazonium salt will not be the final product. Review how fluoroboric acid will react with this intermediate.</p> <p>B. Incorrect! This substituted aniline will not be obtained under these conditions. Go back and review arenediazonium salts and their synthetic utility.</p> <p>C. Incorrect! This nitrobenzene will not be obtained under these conditions. Go back and review arenediazonium salts and their synthetic utility.</p> <p>D. Correct! In the first step, the amine group is transformed to an arenediazonium salt. This intermediate reacts further with fluoroboric acid to give fluorobenzene as the final product.</p>
<p>Solution</p>	<p>(1) Recall the reactions covered in this tutorial.</p> <p>The tutorial covered reactions to synthesize amines and the reactions amines undergo.</p> <p>(2) Determine what kind of reaction is taking place.</p> <p>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 primary aromatic amine. The other reactants are sodium nitrite, aqueous acid and fluoroboric acid. You may have already recognized this series of steps as the formation of an arenediazonium salt followed by quenching of the salt by a nucleophile. This series of steps typically leads to the nucleophile replacing the amine group on the aromatic ring. If you did not, go back and review the reactions in this tutorial.</p> <p>When a primary aromatic amine is treated with sodium nitrite and aqueous acid, an arenediazonium salt is formed. Arenediazonium salts will react with a variety of nucleophiles to replace the nitrogen with different functional groups. Fluoroboric acid displaces the nitrogen and replaces it with a fluorine atom.</p> <p>(3) Predict the product(s).</p> <p>The final product will be a fluorinated aromatic ring. There are two choices above that have fluorine on an aromatic ring. However, knowing the mechanism of this reaction, we know the fluorine will displace the nitrogen altogether and form a bond to the carbon of the aromatic ring that the nitrogen was previously bonded to.</p> <p>The correct fluorinated aromatic must be IV</p> <p>Therefore, the correct answer is (D).</p>