If A Hydrogen Of An Alkane Is Replaced By NH, The Compound Becomes_____a. Alcoholb. Carboxylic Acidc.

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Understanding the transformation of alkanes through substitution reactions is fundamental in organic chemistry. When a hydrogen atom in an alkane is replaced by an amino group (NH_2), the resulting compound exhibits specific chemical properties and classifications. This article explores the implications of such a substitution, comparing the resultant compounds to alcohols and carboxylic acids, and elucidates the chemical structure, nomenclature, reactions, and applications of these derivatives.

Introduction to Alkanes and Their Derivatives

What are Alkanes?

Alkanes are saturated hydrocarbons composed entirely of single bonds between carbon atoms. Their general formula is C_nH_{2n+2}, making them the simplest class of hydrocarbons. Examples include methane (CH_4), ethane (C_2H_6), and propane (C_3H_8). Alkanes are characterized by their chemical stability and non-polar nature, which makes them relatively inert.

Importance of Alkane Derivatives

Modifying alkanes by substituting hydrogen atoms with other functional groups leads to a diverse array of compounds with varied reactivity and applications, such as alcohols, acids, amines, and more. These derivatives are crucial in pharmaceuticals, polymers, and industrial processes.

Substitution of Hydrogen by NH in Alkanes

Understanding the Substitution Reaction

When a hydrogen atom in an alkane is replaced by an amino group (NH_2), the resulting compound is known as an alkylamine. This process involves a substitution reaction where a hydrogen atom is replaced by a functional group containing nitrogen.

Reaction overview:

$$\mathrm{R\text{-}H} + \mathrm{NH_3} \rightarrow \mathrm{R\text{-}NH_2} + \mathrm{H_2}$$

Here, R represents an alkyl group derived from the original alkane.

Formation of Alkylamines

For example, when methane (CH_4) undergoes substitution to replace one hydrogen atom with NH_2:

$$\mathrm{CH_4} + \mathrm{NH_3} \rightarrow \mathrm{CH_3NH_2} + \mathrm{H_2}$$

This yields methylamine, a primary amine.

Differences Between Alcohols, Carboxylic Acids, and Amines

Definition and Structure of Each Class

- **Alcohols:** Organic compounds containing one or more hydroxyl (-OH) groups attached to a saturated carbon atom. Example: ethanol (CH_3CH_2OH).

- **Carboxylic Acids:** Organic acids characterized by the carboxyl group (-COOH). Example: acetic acid (CH_3COOH).

- **Amines:** Organic derivatives where one or more hydrogen atoms of ammonia are replaced by alkyl groups, resulting in compounds with amino ($-NH_2$), imino (-NHR), or quino ($-NR_2$) groups. Example: methylamine (CH_3NH_2).

Functional Groups and Chemical Properties

Compound Type	Functional Group	Example	Basic Chemical Properties
Alcohols	-OH	Ethanol	Polar, capable of hydrogen bonding, soluble in water
Carboxylic Acids	-COOH	Acetic acid	Acidic, can donate a proton (H^+), form salts and esters
Amines	$-NH_2$	Methylamine	Basic, can accept protons, act as nucleophiles

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What Happens When a Hydrogen Is Replaced by NH_2?

Formation of Amines

Replacing a hydrogen atom in an alkane with an amino group results in an alkylamine—a primary amine if only one hydrogen is replaced. The general formula for primary amines is $R–NH_2$, where R is an alkyl group.

Example:
- Methane (CH_4) → Methylamine (CH_3NH_2)
- Ethane (C_2H_6) → Ethylamine ($C_2H_5NH_2$)

Distinction from Alcohols and Carboxylic Acids

- Alcohols are formed when the hydrogen of an alkyl group is replaced by a hydroxyl group (-OH).
- Carboxylic acids are formed through oxidation processes that introduce a carboxyl (-COOH) group, typically from primary alcohols.

The key difference here is that replacing hydrogen with NH_2 yields amines, not alcohols or acids.

Properties and Applications of Amines

Physical and Chemical Properties

- Polarity: Amines are polar due to the nitrogen atom.
- Boiling Points: Generally higher than hydrocarbons but lower than alcohols of similar molecular

weight.

- Basicity: Amines are weak bases because the nitrogen atom can accept a proton.

Reactivity and Uses

- Reactivity: Amines participate in nucleophilic substitution, acylation, and other reactions.
- Uses:
- Building blocks for pharmaceuticals (e.g., antidepressants, antihistamines).
- Intermediates in organic synthesis.
- Components of surfactants and dyes.

Summary: The Correct Choice for the Blank

When a hydrogen atom in an alkane is replaced by NH_2, the resulting compound is an amine, not an alcohol or a carboxylic acid.

Therefore, the correct answer is:

c. Amine

Conclusion

Replacing a hydrogen atom in an alkane with an NH_2 group transforms the compound into an alkylamine, a class of organic compounds with significant industrial and pharmaceutical relevance. This

substitution does not produce alcohols or carboxylic acids, which require different functional groups and oxidation states. Understanding these structural and functional differences is vital for organic synthesis, medicinal chemistry, and industrial applications.

Additional Insights and Practical Reactions

Synthesis of Amines

Amines can be synthesized via:

- Reduction of nitriles: R–CN + 2[H] → R–CH₂–NH₂
- Amination of alkyl halides: R–X + NH₃ → R–NH₂ + HX
- Ammonolysis of alcohols: Long reaction pathways often involve intermediates.

Safety and Handling

Amines are often irritants and can be toxic. Proper safety measures, including gloves and ventilation, are essential during handling.

Final Remarks

Understanding the chemical transformations of alkanes, especially through hydrogen replacement, provides foundational knowledge for organic synthesis. Recognizing that replacing a hydrogen atom with NH_2 yields an amine helps chemists design pathways for creating pharmaceuticals, polymers, and other valuable chemicals. The clear distinction among alcohols, acids, and amines underscores

the importance of functional groups in dictating chemical behavior and application.

In summary:

- Replacing a hydrogen atom in an alkane with NH produces an amine.
- The correct choice for the blank in the statement is c. Amine.
- This transformation is fundamental in organic chemistry and underpins the synthesis of numerous biologically and industrially important compounds.

Frequently Asked Questions

What is the result when a hydrogen atom in an alkane is replaced by an NH group?

The compound becomes an amine.

Replacing a hydrogen in an alkane with NH leads to which type of compound?

It forms an amine derivative.

If a hydrogen atom in an alkane is substituted by NH, what functional group is introduced?

An amino group (-NH2) is introduced.

Does replacing hydrogen with NH in an alkane produce an alcohol or an amine?

It produces an amine.

Is the compound formed by replacing hydrogen in an alkane with NH classified as an alcohol, carboxylic acid, or amine?

It is classified as an amine.

Additional Resources

If a hydrogen of an alkane is replaced by NH, the compound becomes a fascinating topic in organic chemistry that explores the transformation of simple hydrocarbons into more complex and functionalized molecules. This process, involving the substitution of a hydrogen atom with an amino group (NH□), is fundamental in understanding how alkanes can be modified to produce compounds with diverse chemical properties and applications. The question often posed is whether such a substitution leads to the formation of an alcohol or a carboxylic acid, and understanding this requires a deep dive into organic reaction mechanisms, functional group transformations, and the nature of the resulting compounds.

Understanding Alkanes and Their Reactivity

Alkanes are saturated hydrocarbons characterized by single bonds between carbon atoms, with the general formula C□H□□□□. They are relatively inert due to the strength of their C–H bonds and lack of polarity. However, under specific conditions or through certain reactions, alkanes can undergo substitution or functionalization to produce more reactive derivatives.

The substitution of a hydrogen atom in an alkane with an amino group (NH_2) involves replacing a hydrogen atom with an amino group, which is a common step in synthesizing amines—important compounds in pharmaceuticals, agrochemicals, and polymers.

Mechanism of Hydrogen Replacement with NH_2

Replacing a hydrogen atom in an alkane with an amino group typically proceeds via radical substitution or nucleophilic substitution, depending on the conditions:

- Radical Substitution: Usually occurs under UV light or high-energy conditions, where a hydrogen atom is abstracted to form a radical, which then reacts with nitrogen-containing radicals or compounds.
- Nucleophilic Substitution: Less common for alkanes due to their inertness but can occur in the presence of certain catalysts or reagents that activate the C–H bond.

The key point is that when a hydrogen atom in an alkane is replaced by NH_2, the resulting compound is an alkylamine (or more precisely, an amine derivative of the alkane).

From Alkane to Alkylamines: The Immediate Product

When a hydrogen atom in an alkane is replaced by NH_2, the immediate product is an alkylamine. For example:

- Replacing a hydrogen in methane (CH_4) with NH_2 results in methylamine (CH_3NH_2).
- Replacing a hydrogen in ethane (C_2H_6) results in ethylamine ($C_2H_5NH_2$).

Features of Alkylamines:

- Contain an amino group attached to an alkyl chain.
- Exhibit basic properties due to the lone pair on nitrogen.
- Can participate in further reactions, including oxidation, acylation, and more.

Pros and Cons of Alkylamines:

Pros	Cons
Useful intermediates in organic synthesis	Can be toxic and irritating to skin and eyes
Have applications in pharmaceuticals and dyes	Some are volatile and flammable
Possess basicity, useful in catalysis	Their reactivity requires careful handling

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Does Replacing a Hydrogen in an Alkane with NH_2 Lead to an Alcohol or a Carboxylic Acid?

The core question is whether such a substitution results in an alcohol or a carboxylic acid. The answer lies in the nature of the functional groups involved and the subsequent chemical transformations.

Initial Substitution: Formation of an Amine

- When a hydrogen is replaced directly by NH_2, the immediate product is an amine (alkylamine).
- No alcohol or carboxylic acid is formed directly from this substitution.

Transformations Toward Alcohols or Carboxylic Acids

To convert an alkylamine into an alcohol or a carboxylic acid involves additional oxidation steps:

- Amine to Alcohol: Not a straightforward transformation; typically, amines do not oxidize directly into alcohols. Instead, amines are often oxidized to nitro compounds or other derivatives.
- Amine to Carboxylic Acid: Requires multiple oxidation steps, often involving nitrile intermediates or other functional group transformations.

Pathways to Alcohols and Carboxylic Acids from Alkylamines

While the direct replacement of a hydrogen atom in an alkane with NH_2 results in an amine, chemical pathways can convert these amines into alcohols or acids:

1. Conversion to Alcohols

- Via Nitration and Hydrolysis:
Typically, amines can be converted into nitriles ($-C\equiv N$) through substitution reactions, which can then be hydrolyzed to produce carboxylic acids, but not directly to alcohols.
- Reductive Amination:
In certain cases, amines can be converted into alcohols via reduction, but this is more commonly used to synthesize amines from aldehydes or ketones rather than the other way around.

2. Conversion to Carboxylic Acids

- Oxidation of Amine Derivatives:
Through oxidation of primary amines, nitriles, or related compounds, it is possible to produce

carboxylic acids. For example, some primary amines can be oxidized to nitriles, which can then be hydrolyzed into acids.

- From Alkyl Halides:

Alkyl halides can be oxidized to carboxylic acids via oxidation pathways involving the formation of aldehydes and then acids.

Summary:

- Directly replacing a hydrogen in an alkane with NH_2 does not produce an alcohol or a carboxylic acid.
- Additional steps involving oxidation and functional group transformations are necessary to convert an alkylamine into these acids or alcohols.

Conclusion: The Final Answer

Considering all the above, the straightforward replacement of a hydrogen atom in an alkane with NH_2 results in an alkylamine—a nitrogen-containing compound with basic properties. It does not directly produce an alcohol or a carboxylic acid. To obtain either of these functional groups from an alkylamine, additional chemical reactions are required, primarily involving oxidation processes.

Therefore, the correct answer to the question:

If a hydrogen of an alkane is replaced by NH, the compound becomes b. Carboxylic Acid or a. Alcohol ?

is neither a. Alcohol nor b. Carboxylic Acid by direct substitution. The immediate product is an amine, and further transformations are needed to reach alcohols or acids.

In summary:

- The initial product is an alkylamine.

- Conversion into alcohols or acids involves additional steps like oxidation.

- The process exemplifies the versatility of organic synthesis in modifying hydrocarbons into more functionalized compounds.

Final Remarks

This exploration underscores the importance of understanding reaction pathways in organic chemistry. Recognizing that substitution reactions often serve as starting points rather than final products enables chemists to design processes for synthesizing a wide array of compounds, including alcohols and acids, from simple hydrocarbons. The transformation from an alkane to more complex molecules like alcohols or acids is a testament to the power of functional group chemistry and the significance of stepwise synthesis in chemical research and industry.

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