Organic Nomenclature Game

Overview: This activity is designed to help students in organic chemistry master nomenclature. The game can be adjusted to incorporate the nomenclature topics being covered in an organic chemistry course. The most basic version can be played once the nomenclature of alkanes and haloalkanes has been covered. Functional groups can be incorporated as they are covered in the course, as well as stereochemistry.

The game begins with the line-angle structure of a butane molecule which is drawn on the board. The first player rolls a six-sided die and uses the number assignments below to add a new group to butane molecule. Every student must then determine the correct name of the new molecule. Points can be awarded for correct names for a competition. The next player rolls the die and adds a another group to the structure drawn by the first player. After each turn, students must give the correct name of the new compound as it becomes increasingly larger and more complex. An example of a sample game can be found on the site.

Requirements:

- one six-sided die
- referee (chemistry instructor)
- white board or overhead screen projector
- nomenclature software can be useful

Alkanes and Haloalkanes:

Die Number Assignment:
1 = add a methyl group
2 = add an ethyl group
3 = add a propyl group
4 = add an isopropyl group
5 = add a halogen of the roller's choice (F, Cl, Br, or I)
6 = Player's choice

Incorporating Alkenes:

Die Number Assignment:
1 = add a methyl group
2 = add an ethyl group
3 = add a propyl group
4 = add an isopropyl group
5 = add a halogen of the roller's choice (F, Cl, Br, or I)
6 = convert a single bond to a double bond*

*double bonds should be separated by at least one carbon
*students can be asked to assignment *E*/*Z* stereochemistry of the parent carbon chain if relevant

If alkynes have also been covered in the course, a player who has rolled a 6 may opt to convert a double bond on the molecule to a triple bond if possible.

Incorporating Alcohols:

Die Number Assignment:
1 = add a methyl group
2 = add an ethyl group
3 = add a propyl group
4 = add an isopropyl group
5 = add a halogen of the roller's choice (F, Cl, Br, or I)
6 = add a hydroxy group*

* hydroxy groups must be on separate carbons on the parent chain

Die Number Assignment for Amines:
1 = add a methyl group
2 = add an ethyl group
3 = add a propyl group
4 = add an isopropyl group
5 = add a halogen of the roller's choice (F, Cl, Br, or I)
6 = add an amino group

Die Number Assignment for Carbonyls:
1 = add a methyl group
2 = add an ethyl group
3 = add a propyl group
4 = add an isopropyl group
5 = add a halogen of the roller's choice (F, Cl, Br, or I)
6 = add an oxo group*

*Students can use the oxo group to create either an aldehyde or a ketone (however a maximum of two –CHO groups can be placed on the parent chain. At this point it becomes necessary to introduce the concept of functional-group priority. This also allows the referee to incorporate the previously-used functional groups (see Advanced Rules below).

Play:

- Players roll die to determine who goes first.
- The first player rolls the die to determine which new group must be added to the butane molecule.
- The roller adds the group to any of the four carbons on the butane molecule (drawn on board).
- Each player (including the die roller) writes on a sheet of paper what they think the correct name of the new molecule is.
- Once everyone has come up with a name, the referee writes the correct name on the board
- Each player who correctly named the compound receives one point. Players that did not name the molecule correctly need to write the correct name underneath their name. This ends Round 1.
- The next player rolls the die and adds the assigned group somewhere on the new molecule from Round 1
- Each player names the new molecule and the steps above are repeated, ending Round 2.
- Play ends when the rolled substituent cannot be added without violating the rules below ***or*** when every player gives an incorrect name

Rules:

- Parent chain cannot go over ten carbons. This rule can be ignored if the curriculum covers longer chains.
- Any double bonds or halogens should be located ***or become*** a part of the parent chain.
- Substituents coming off the parent chain should remain simple (methyl, ethyl, propyl, isopropyl, butyl, *tert*-butyl, etc.) In other words, substituents requiring parentheses are not allowed. This rule can be ignored if complex substituents are a part of the curriculum.

Scoring:

- Each player that names the molecule correctly in each round receives one point.
- If the roller draws an impossible compound (i.e. pentavalent carbon), the roller and each player that doesn't catch the mistake lose one point. Players who realize that the molecule is incorrect write the words "impossible compound" as the name.
- If the roller decides that it is not possible to add the assigned substituent without violating the rules, the referee asks the other players if they agree (writing their answer on their paper).

    1. If the roller was incorrect, the roller and players that agreed lose a point. Play then continues with a new roll from the next player.
    2. If the roller was correct, players that disagreed lose a point. This ends this game and the player with the most points wins.

Tie Breakers:

- In the event of a tie, the player that correctly answered more of the larger, more complicated molecules wins. This can be determined by adding up all of the Round numbers in which the player provided the correct name.
- If this still results in a tie, the referee determines the winner based one which player made the fewest and/or least egregious errors.

Optional Rules:

- requiring *cis*/*trans* or *E*/*Z* stereochemical information for double bonds
- requiring *R*/*S* stereochemical information when a chirality center is formed
- converting a double bond to a triple bond (if possible) when a 6 is rolled for alkene nomenclature
- allowing *tert*-butyl, *sec*-butyl and/or isobutyl groups
- imposing a time limit (good for team play)
- starting with a different molecule other than a butane

Optional Play:

- spelling bee format - where a player is eliminated from the game for first incorrect name
- allowing players to divide up into teams in which they work together to provide a single answer
- 1 on 1 play between two students using amended scoring rules below:
    a. roller receives extra point if they change the end from with the parent chain is numbered
    b. roller receives extra point if they change the stereochemistry at a double bond
    c. roller receives extra point if they change the stereochemistry at an asymmetric center

Advanced Version for Naming Compounds with Multiple Functional Groups

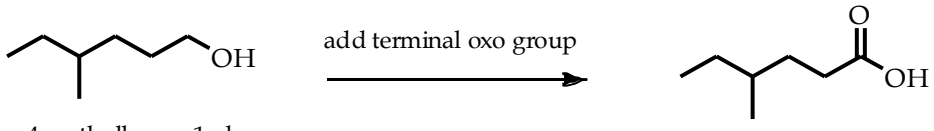
- use two dice to include more groups
- includes alcohols, amines, alkoxy groups, aldehydes, ketones, carboxylic acids, esters, and amides
- list of the nomenclature priority rules may be used

Dice Number Assignment:

2 = add an oxo group to a ***terminal*** carbon to form an aldehyde[1]
3 = add an oxo group to an ***internal*** carbon to form a ketone
4 = add an amino group (may be used to convert an aldehyde to an amide)
5 = add an isopropyl group[2]
6 = add a propyl group[2]
7 = add a methyl group[2]
8 = add an ethyl group[2]
9 = add a halogen of the roller's choice (F, Cl, Br, or I)
10 = add a hydroxyl group (may be used to convert an aldehyde to a carboxylic acid)
11 = convert a single bond to double bond (or a double bond to a triple bond)[3]
12 = roller's choice (roller can add any of the above)

[1]A terminal oxo group may be used to produce other functional groups depending on what type of group is bonded to the terminal carbon.

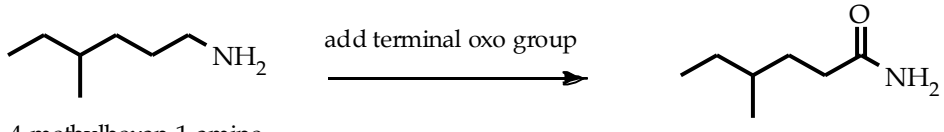
For example, adding an oxo group to a terminal carbon that is bonded to a hydroxyl group will convert an alcohol to a carboxylic acid.



4-methylhexan-1-ol

4-methylhexanoic acid

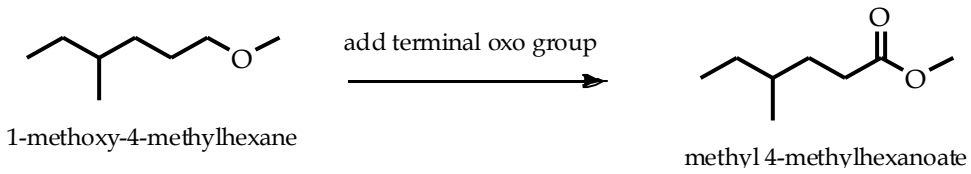
converting a terminal amino substituent to an amide:



4-methylhexan-1-amine

4-methylhexanamide

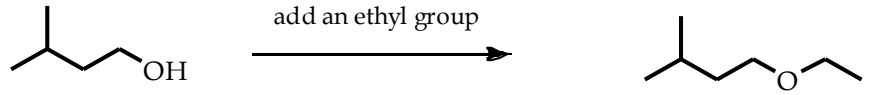
converting a terminal alkoxy group to an ester:



1-methoxy-4-methylhexane

methyl 4-methylhexanoate

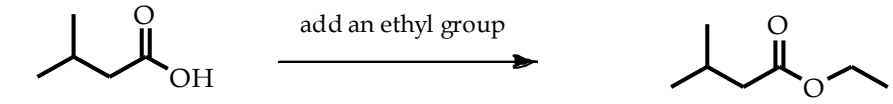
[2]Alkyl groups may be used to replace the H atom on a hydroxyl group to create an alkoxy group (ether).



3-methylbutan-1-ol

1-ethoxy-3-methylbutane

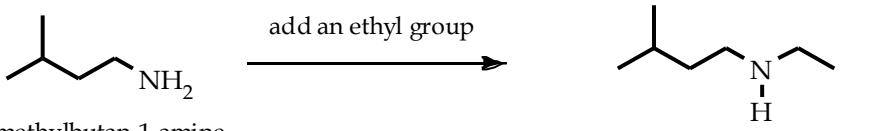
[2]Alkyl groups may be used to replace the H atom on a carboxyl group to create an ester.



3-methylbutanoic acid

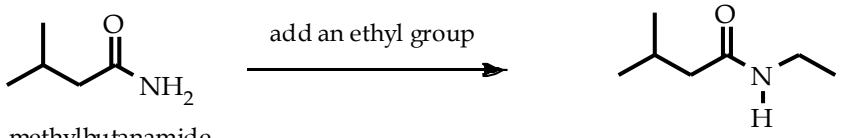
ethyl 3-methylbutanoate

[2]Alkyl groups may be used to replace the H atom on an N atom on either an amino group or amide.



3-methylbutan-1-amine

N-ethyl-3-methylbutan-1-amine

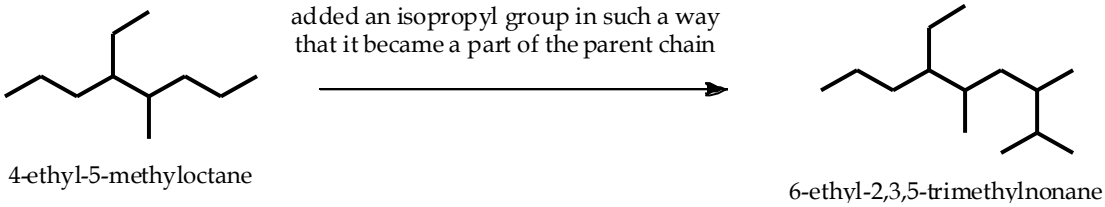


3-methylbutanamide

N-ethyl-3-methylbutanamide

Strategies for Roller:

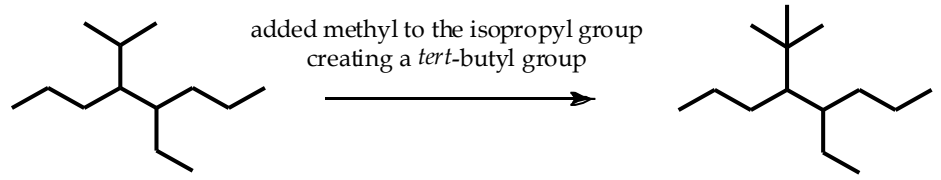
- adding the assigned group in such a way that it changes the end from which the parent chain is numbered
- adding the assigned group in such a way that it changes the stereochemistry at a stereocenter
- adding an isopropyl group close enough to the end of the parent chain so that is not named as a substituent, but becomes a part of the parent chain (see example below)



4-ethyl-5-methyloctane

6-ethyl-2,3,5-trimethylnonane

- adding a group in such a way that it converts a substituent to a different substituent (i.e. adding a methyl group to an isopropyl, converting it to a *tert*-butyl group)



4-ethyl-5-isopropyloctane

4-*tert*-butyl-5-ethyloctane

This also represents a good example of how to change the end from which the parent chain is numbered,