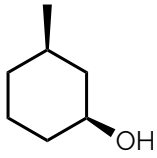
Cyclohexane - *Worksheet*

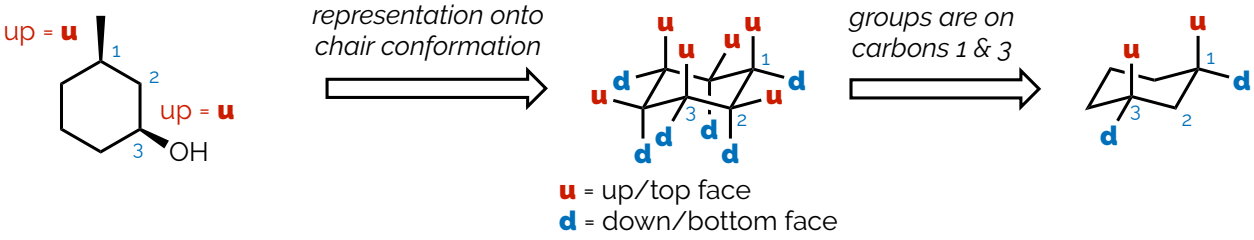
Question 1

Draw the two chair conformations of the molecule below:

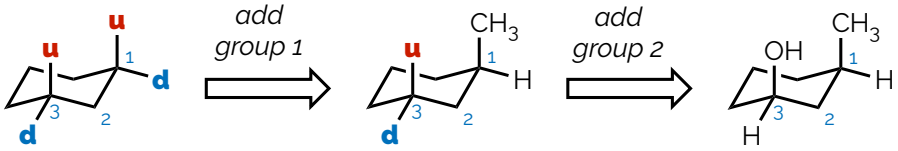


Answer 1

First number the atoms of the ring so that the substituents have the correct relationship (they are placed on the correct carbon atoms). The identify which face of the ring the substituents are on. In this case they are both bold wedges so are on the top face. Draw a chair conformation. Number the atoms. This will determine the orientation of the first conformation. By starting the numbering on the carbon on the far right of the molecule you can see that a substituent pointing upwards will be axial. The orientation of the groups on the third atom around is fixed by the shape of the original chair.



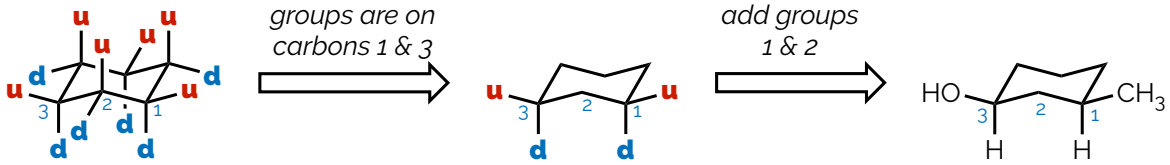
Now you can add the groups to the chair conformation. On atom one you would place a methyl group in the upward position. This is avail. I would ad the downward hydrogen as well, it makes the diagrams look clearer (when there are only a limited number of substituents) and emphasises the orientation.



conformation 1

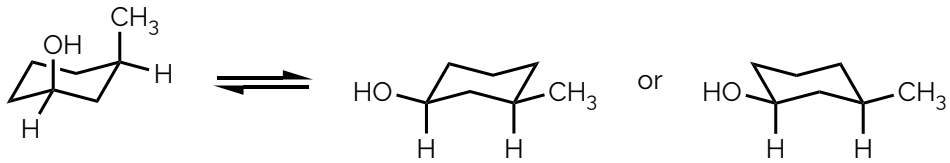
Count around to the third atom and you can see that an upwards group must again be axial. So add the alcohol group. This is the first conformation. Students frequently ask if it is important which way you count the atoms, clockwise or anticlockwise. The answer is yes. If we look at the skeletal representation, the hydroxyl group is to the right of the methyl group, so you must match this. If you don't you have drawn the enantiomer of the original molecule (for first years, your marker would probably give you full marks but realise you are wrong!).

To draw the second conformation, start numbering the chair conformation on the adjacent atom. Note how the upward group is now in an equatorial position. The ring has undergone ring flipping. After that the process is the same.



conformation 2

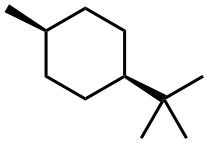
The method above is a cheat or trick. Really, you should understand that ring flipping twists the carbon atoms moving them up and down. As such, the drawing below shows how the two conformations could be drawn:



conformation 1 **conformation 2**

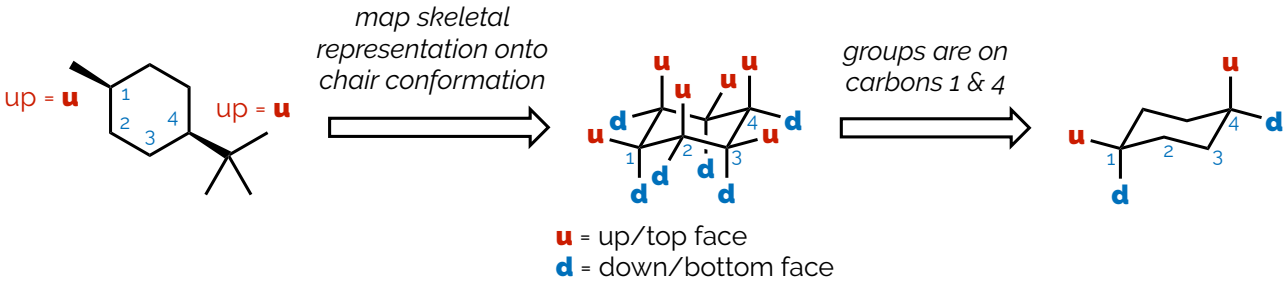
Question 2

What is the most stable conformation of the molecule below?:

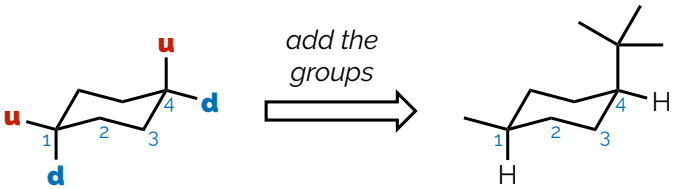


Answer 2

You aren't expected to be able to look at a cyclohexane and know what the favoured conformation is. No, this questions is basically saying draw both conformations and then determine which would be favoured. The substitution pattern may be different to question 1 but the process is exactly the same, you are going to map the skeletal representation on to the chair:

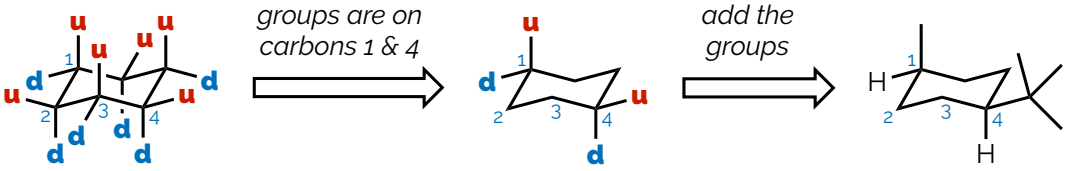


The first conformation is given below:

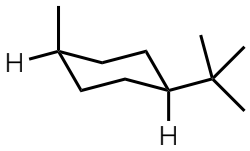


conformation 1

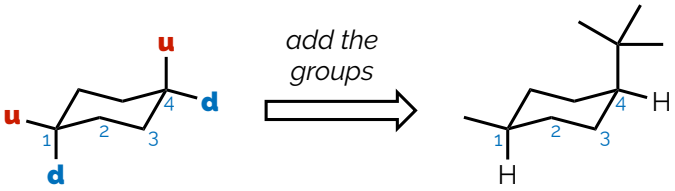
To draw the second conformation, either start the mapping process by numbering the carbons from an adjacent carbon atom or perform the ring flipping in your head and draw atom 1 upwards:



conformation 2



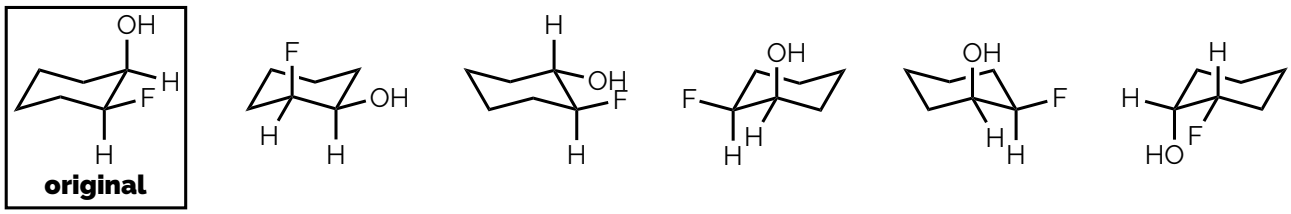
The favoured conformation has the largest group in the equatorial position to minimise 1,3-diaxial interactions so, it is ***conformation 2****.*



conformation 1

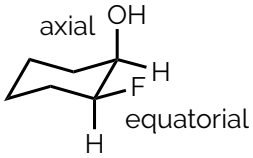
Question 3

Identify the stereochemical relationship between the first molecule in the square and the other five representations. They will be either enantiomer, diastereomer, conformation or the same.



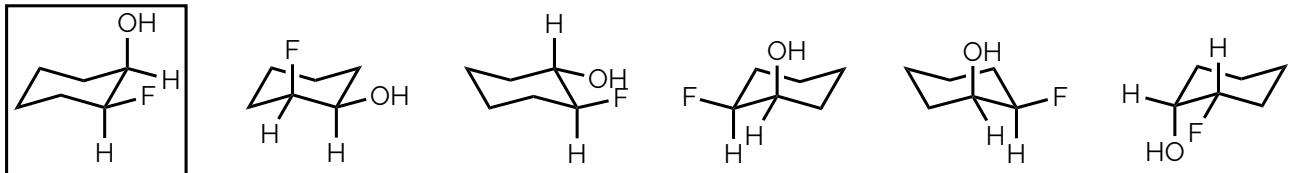
Answer 3

The purpose of this question is to get you used to manipulating drawings and recognising how they relate to one another. The original molecule has the two groups on adjacent carbon atoms. The groups are cis *to each other, meaning they are both on the same face of the molecule, with the alcohol in an axial position and the fluorine atom equatorial. For those of you that have read the stereochemical descriptor summary, I have also provided its name:*



(1*R*,2*S*)-2-fluorocyclohexan-1-ol

In the first molecule the substituents are cis *(on the same face) and are on adjacent atoms. The alcohol is now equatorial and the fluorine atom axial so it is the other chair conformation of the original.*



(1*R*,2*S*) different conformation

(1*S*,2*S*) diastereomer

(1*R*,2*S*) same molecule

(1*S*,2*R*) enantiomer

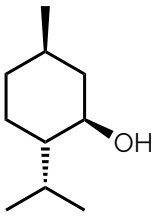
(1*R*,2*S*) same

In the second molecule, the groups are on opposite sides of the molecule, they are trans*, this means this is a diastereomer of the original. The third molecule is the same molecule, in the same conformation, just rotated around an axis. The fourth molecule is an enantiomer of the original. The groups are adjacent, they are on the same face (*cis*), but, as you go clockwise around the molecule they are in a different order. In other words, they are the mirror image. Finally, the last molecule is the same as the original and is in the same conformation, the ring has been rotated through 180˚.*

Many people struggle to see the relationship between the various drawings, having a hard time to picture the molecules in three dimensions. If you are one of these then I would recommend making models and using them to understand the relationships between the drawings.

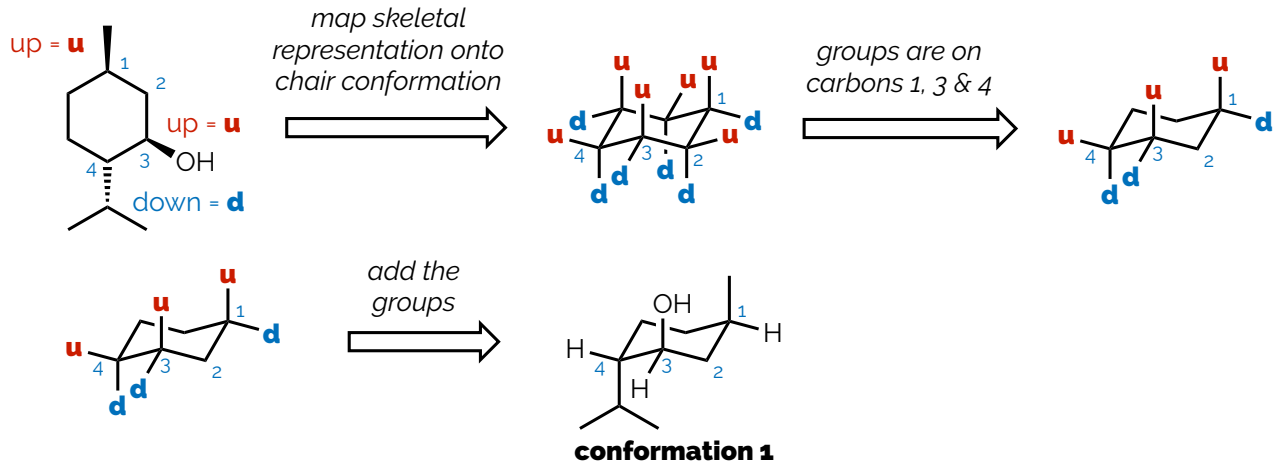
Question 4

Draw the two chair conformations of menthol (below) and determine which conformation is the most stable.



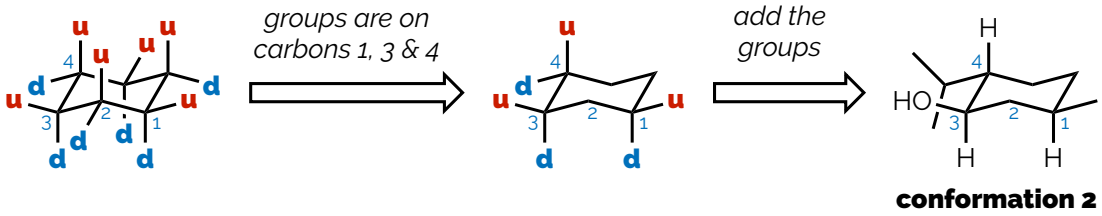
Answer 4

There is no difference between this question and any of the ones above. Menthol may have three substituents instead of two but the same process is involved. What you have covered in this summary applies to any saturated six-membered ring regardless of how many substituents are on the ring.



Number the original ring so that you know where each group must go. Determine which face the groups are on. Draw a chair conformation. Number its atoms so that you know where to map the groups. Add the groups. Remember, once you have chosen the first atom to place the first substituent and put it either axial or equatorial, all the the other groups are fixed. They can only go in one positions as indicated by the chair conformation. In this case, all the substituents are axial.

To draw the second conformation, I will start numbering the ring one carbon around. This will mean that all the upwards groups that were originally axial will be equatorial and vice versa.



The conformation that has all the groups equatorial is the most stable as there are no 1,3-diaxial interactions.