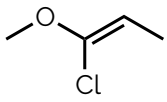
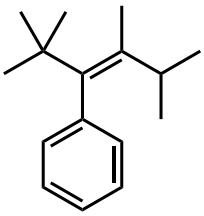
# Stereochemistry 2: Naming - *Worksheet*

## Question 1

Give the stereochemical descriptor, *E* or *Z*, for each of the following alkenes:




1-chloro-1-methoxyprop-1-ene



(2,2,4,5-tetramethylhex-3-en-3-yl)benzene

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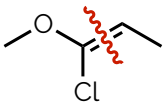
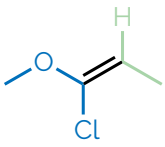
## Answer 1

Molecule 1

1. divide in half



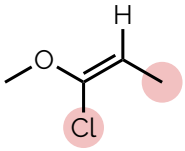

2. determine highest priorities




O (8) *vs* Cl (17) Cl = highest

H (1) *vs* C (6) C = highest

3. assign descriptor




same side

***Z***

*Step 1 - divide the alkene in two*

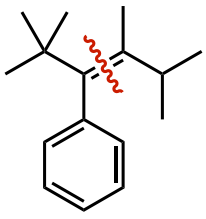
*Step 2 - determine the highest priority group (substituent) on each half of the alkene. For the left-hand side, you compare the first two atoms joined to the carbon; one is an oxygen atomic number 8 and the other is chlorine, atomic number 17. Chlorine has the highest priority. For the right-hand side, it is carbon versus hydrogen, which carbon obviously wins.*

*Step 3 - if the highest priority atoms are on the same side the descriptor is Z while if they are on opposite sides it is* E. *Here they are on the same side so the descriptor is* **Z**.

*The molecule is called (Z)-1-chloro-1-methoxyprop-1-ene.*

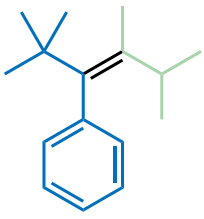
Molecule 2

1. divide in half



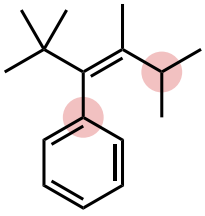
| Group | ***t*-Bu** | **Ph** |
|---|---|---|
| 1st atom | C | C |
| 2nd atom | C,C,C | C,C,C |
| 3rd atom | H,H,H | C,C,H |
| priority | | **highest** |

2. determine highest priorities



| Group | $CH_3$ | ***i*Pr** |
|---|---|---|
| 1st atom | C | C |
| 2nd atom | H,H,H | C,C,H |
| priority | | **highest** |

3. assign descriptor



same side

***Z***

*Step 1 - divide the alkene in two*

*Step 2 - determine the highest priority group (substituent) on each half of the alkene. We picked this example as it is not so straightforward. It is a hydrocarbon so you are going to have to learn how to determine the difference between similar groups (no obvious heteroatoms signposting the difference). Starting on the left-hand side, the atoms attached directly to the alkene are both carbon. They are the same at this position so it is necessary to move to the second atom. The top substituent is a tert-butyl group, the carbon is joined to three more carbon atoms. The bottom substituent is a phenyl group and the carbon is joined to two carbon atoms. One of the bonds is a double bond (in this resonance structure), and is considered the same as two bonds to carbon. This means this substituent is also attached to three carbon atoms. There is still no difference and we must move to the third atom along the chain. For the tert-butyl group, which ever chain we move along the third atoms will always be hydrogen. For the phenyl substituent the third atom will be either a carbon or hydrogen. As carbon has a higher priority than hydrogen. At last, there is a difference. The phenyl group is higher priority than the tert-butyl group.*

*What about the right-hand side? Again, the first atom we come to in both substituents (methyl versus isopropyl) is a carbon atom. This means we must move to the second atom in the chain. For the methyl group this is a hydrogen while for the isopropyl group this is a carbon. The isopropyl group has the higher priority.*

*Step 3 - if the highest priority atoms are on the same side the descriptor is Z while if they are on opposite sides it is E. Here they are on the same side so the descriptor is* **Z**.

*The molecule is called (Z)-(2,2,4,5-tetramethylhex-3-en-3-yl)benzene.*

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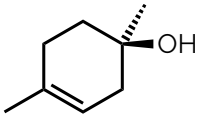
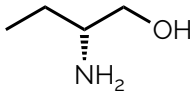
## Question 2

Give the stereochemical descriptor, *R* or *S*, for each of the following molecules:




1,4-dimethylcyclohex-3-en-1-ol




2-aminobutan-1-ol

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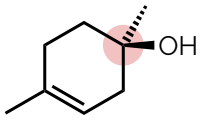
## Answer 2

Molecule 1

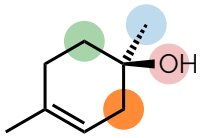
*Step 1 - Identify any stereocentres*

*First look for a tetrahedral atom with four different groups coming off it. In the first molecule this is the carbon of the alcohol group.*



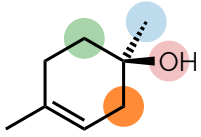

*Step 2 - Assign priorities to the four substituents*

*This follows the same system as the alkenes. Move along each group until you find a difference. The highest priority group (priority 1) is the .alcohol as oxygen (atomic number 8) has a higher priority than carbon (atomic number 6), the first atom we encountered on the other three substituents.*



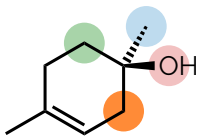

| **Group** | **OH** | **$CH_3$** | **$CH_2CH_2C$** | **$CH_2CH{=}C$** |
|---|---|---|---|---|
| 1st atom | O | C | C | C |
| **priority** | **1** | | | |

*Moving to the 2nd atom on each group you should be able to determine the lowest priority group (priority 4). The second atom on the methyl group is hydrogen while one of the second atoms on the other two groups is a carbon. Both the other groups have a higher priority (but you cannot differentiate them yet as they have the same second atom).*



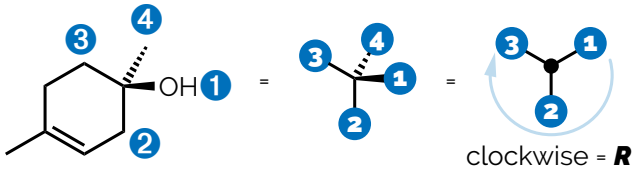

| **Group** | **OH** | **$CH_3$** | **$CH_2CH_2C$** | **$CH_2CH{=}C$** |
|---|---|---|---|---|
| 1st atom | O | C | C | C |
| 2nd atom | | H,H,H | C,H,H | C,H,H |
| **priority** | **1** | **4** | | |

*So you move to the third atom along each chain and finally there is a difference between the remaining groups One of them is linked to two carbon atoms while the other only has a single carbon atom. The first has the higher priority.*




| Group | OH | $CH_3$ | $CH_2CH_2C$ | $CH_2CH{=}C$ |
|---|---|---|---|---|
| 1st atom | O | C | C | C |
| 2nd atom | | H,H,H | C,H,H | C,H,H |
| 3rd atom | | | C,H,H | C,C,H |
| **priority** | **1** | **4** | **3** | **2** |

*Step 3 - Orientate the molecule so that the lowest priority is pointing away from you (downwards into the page)*
*Fortunately, the methyl group, which is priority 4, is already pointing away so you don't have to do anything.*




*Step 4 - Draw an arrow connecting 1-2-3 and assign the stereochemical descriptor.*
*The arrow is clockwise which corresponds to **R** (as it rotates to the **R**ight). If the arrow had gone anti-clockwise then the descriptor would have been **S**.*

*The molecule is called (R)-1,4-dimethylcyclohex-3-en-1-ol.*

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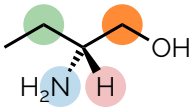
## Answer 2

Molecule 2

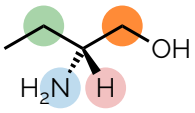
*Step 1 - Identify any stereocentres*
*First look for a tetrahedral atom with four different groups coming off it. Remember that our skeletal diagrams omit the hydrogen atoms. The stereocentre is shown below:*


*Step 2 - Assign priorities to the four substituents*
*As before we move outwards from the stereocentre. First, compare the four atoms attached directly to the stereocentre. In this case, you should be able to identify the highest priority (1 = N) and the lowest priority (4 = H) but the two carbon chains are the same at the first atom.*



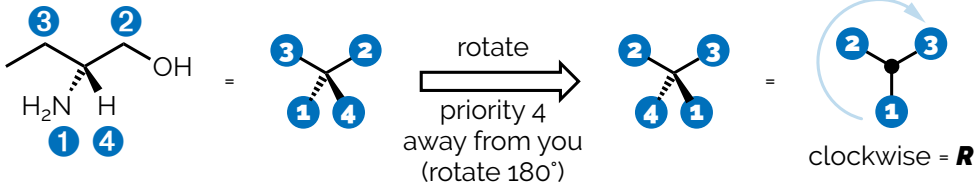

| Group | H | $NH_2$ | $CH_2CH_3$ | $CH_2OH$ |
|---|---|---|---|---|
| 1st atom | H | N | C | C |
| **priority** | **4** | **1** | | |

*Moving to the 2nd atom on each of the remaining groups and you can differentiate them. The left-hand chain has carbon or hydrogen while the right-hand has an oxygen atom so has a higher priority.*




| Group | H | $NH_2$ | $CH_2CH_3$ | $CH_2OH$ |
|---|---|---|---|---|
| 1st atom | H | N | C | C |
| 2nd atom | | | C,H,H | O,H,H |
| **priority** | **4** | **1** | **3** | **2** |

*Step 3 - Orientate the molecule so that the lowest priority is pointing away from you (downwards into the page)*
*With the priorities determined, you now have to orientate the molecule so that the lowest priority is pointing backwards. The lowest priority is the hydrogen atom. It needs to be pointing in the opposite direction. This requires the molecule to be rotated through 180˚. Be careful, this is where most mistakes are made.*




*Step 4 - Draw an arrow connecting 1-2-3 and assign the stereochemical descriptor.*
*The arrow is clockwise which corresponds to **R** (as it rotates to the **R**ight). If the arrow had gone anti-clockwise then the descriptor would have been **S**.*

*The molecule is called (R)-2-aminobutan-1-ol.*

*In our experience it is the rotation of the molecule that causes the most problems, with many students accidentally inverting the stereocentre and thus getting the wrong answer. One solution is to 'cheat'. Don't change the orientation of the molecule and simply determine the stereochemical descriptor as normal by drawing a line connecting 1-2-3 and seeing which direction it rotates in. BUT before you write the answer down remember that the lowest priority is pointing in the wrong direction so the real answer must be the opposite to what you just determined. This works well and prevents the errors of re-drawing the molecule BUT only if you know which direction the lowest priority SOULD be facing. It should be away from you.*

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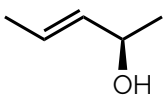
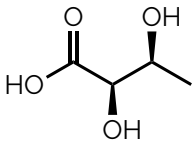
## Question 3

Determine the full name of the following molecules::

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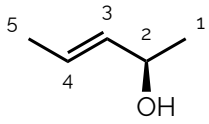
## Answer 3

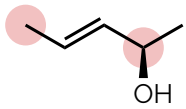
Molecule 1

*The molecule contains an alcohol so the suffix will be **-ol**. It also contains an alkene, which means the parent will end with **-ene**. The parent is a five carbon chain so is based on **pentane**. Now all you have to do is describe the position of each functional group. The numbering will give the major functional group (the alcohol) the lowest possible number so we have:*




pent-3-en-2-ol

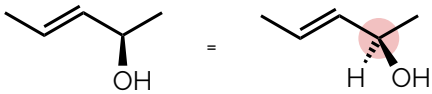
*But this name could describe either enantiomer or the diastereomer. For the name to be specific to the molecule drawn you must add the stereochemical descriptors. Let's start with the alkene. The full process involves determining the highest priority substituent at either end of the alkene, but this molecule is a simple disubstituted alkene so we know the two carbon chains have a higher priority than the two hydrogen atoms. The two substituents are on opposite sites of the alkene so it is an **E** alkene.*



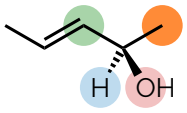

opposite = ***E***

*Finally, you need to determine the stereochemical descriptor for the alcohol (spoiler, it is the other stereocentre).*

*Step 1 - Identify any stereocentres*
*It's the alcohol carbon:*

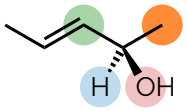



*Step 2 - Assign priorities to the four substituents*
*Move outwards from the stereocentre. First, compare the four atoms attached directly to the stereocentre. In this case, you should be able to identify the highest priority (1 = O) and the lowest priority (4 = H) but the two carbon chains are the same at the first atom.*



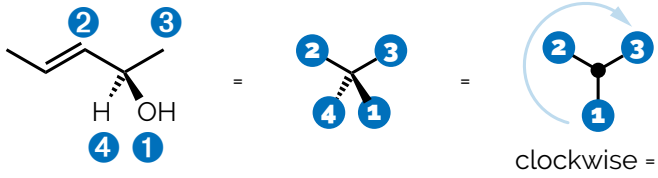

| **Group** | **OH** | **H** | **CH=CHCH$_3$** | **CH$_3$** |
|---|---|---|---|---|
| 1st atom | O | H | C | C |
| **priority** | **1** | **4** | | |

*Moving to the 2nd atom on each of the remaining groups and you can differentiate them. The alkene has a higher priority than the methyl group.*



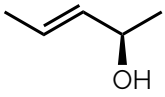

| Group | OH | H | $CH=CHCH_3$ | $CH_3$ |
|---|---|---|---|---|
| 1st atom | O | H | C | C |
| 2nd atom | | | C,C,H | H,H,H |
| **priority** | **1** | **4** | **2** | **3** |

*Step 3 - Orientate the molecule so that the lowest priority is pointing away from you (downwards into the page)*
*Luckily, the hydrogen is already pointing away from you so nothing to do here.*




*Step 4 - Draw an arrow connecting 1-2-3 and assign the stereochemical descriptor.*
*The arrow is clockwise which corresponds to **R**.*

*Finally, put it all together. As there is only one alkene and only one tetrahedral stereocentre, we do not have to identify which atom they belong to and simply put the descriptors at the start of the name as follows:*




(*R*,*E*)-pent-3-en-2-ol

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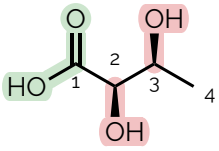
## Answer 3

Molecule 2

*Start by determining the name of the structure of the molecule and then worry about adding the stereochemical descriptors. The major functional group, which will make the suffix of the name, is a carboxylic acid. This means the suffix will be **-oic acid**. The parent is the longest chain of carbon atoms containing the major functional group. It is four carbons long so the parent will be based on **butane**. The numbering of the chain puts the carboxylic acid on carbon 1. The minor functional groups are alcohols on carbons 2 and 3. This means the prefix will be **2,3-dihydroxy**.*

major functional group = **carboxylic acid**

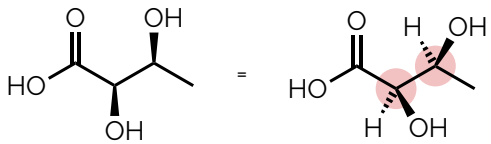



minor functional group = 2 x **alcohol**

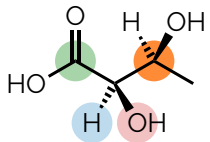
*If you put all of this together you get **2,3-dihydroxybutanoic acid**.*

*This name could refer to any one of four stereoisomers so it is necessary to specify the shape by giving it the correct stereochemical descriptors.*

*Step 1 - Identify any stereocentres*
*There are two stereocentres, carbon atoms with four different groups attached, as indicated by the red circles:*

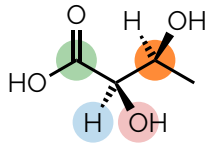



*Step 2 - Assign priorities to the four substituents*
*If we start by looking at the stereocentre on C2 The highest (1 = OH) and lowest (4 = H) priorities are easiest to spot. They can be determined by the atomic number of the atoms attached directly to the stereocentre.*



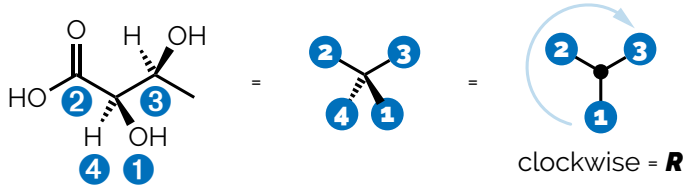

| Group | OH | H | $CO_2H$ | $CH(OH)CH_3$ |
|---|---|---|---|---|
| 1st atom | O | H | C | C |
| **priority** | **1** | **4** | | |

*You need to move to the second atom to differentiate the remaining two groups. The carboxylic acid, with three bonds to oxygen, has a higher priority than the alcohol with a single bond to oxygen.*



| Group | OH | H | $CO_2H$ | $CH(OH)CH_3$ |
|---|---|---|---|---|
| 1st atom | O | H | C | C |
| 2nd atom | | | O,O,O | O,C,H |
| **priority** | **1** | **4** | **2** | **3** |

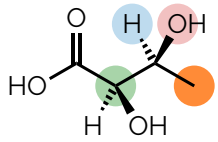
*Step 3 - Orientate the molecule so that the lowest priority is pointing away from you (downwards into the page)*
*Luckily, the hydrogen is already pointing away from you so nothing to do here.*




*Step 4 - Draw an arrow connecting 1-2-3 and assign the stereochemical descriptor.*
*The arrow is clockwise which corresponds to **R**. The alcohol on C2 has an R stereochemical descriptor. As there are multiple stereocentres, it is necessary to assign this descriptor to an atom and it is called 2R as it is on C2.*

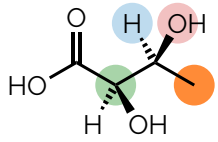
*Next we repeat the process for the second stereocentre, the one on C3.*

*Step 2 - Assign priorities to the four substituents*
*Again, the highest (1 = OH) and lowest (4 = H) priorities are easiest to spot as they can be assigned from the atoms directly attached to C3.*



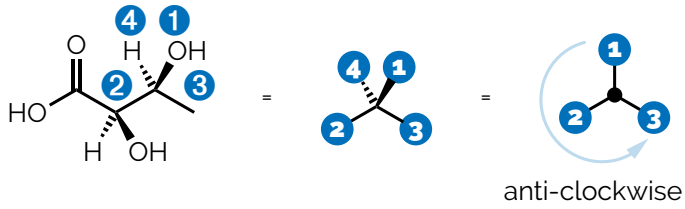
| Group | OH | H | $CH(OH)CO_2H$ | $CH_3$ |
|---|---|---|---|---|
| 1st atom | O | H | C | C |
| **priority** | **1** | **4** | | |

*The second atoms in the chain allow the differentiation of the remaining groups. The alcohol, with an oxygen atom, has higher priority than the methyl group with its three hydrogen atoms.*



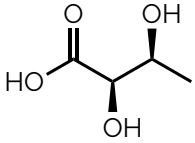
| Group | OH | H | $CH(OH)CO_2H$ | $CH_3$ |
|---|---|---|---|---|
| 1st atom | O | H | C | C |
| 2nd atom | | | O,C,H | H,H,H |
| **priority** | **1** | **4** | **2** | **3** |

*Step 3 - Orientate the molecule so that the lowest priority is pointing away from you (downwards into the page)*
*Again, it (4 = H) is already orientated downwards so you are good to go:*




*Step 4 - Draw an arrow connecting 1-2-3 and assign the stereochemical descriptor.*
*Once the lowest priority is pointing in the correct direction it is possible to ignore it, then draw an arrow connecting 1-2-3. The arrow is anti-clockwise and corresponds to **S**. It is on C3 so is 3S.*

*Finally, put it all together and the molecule is **(2R,3S)-2,3-dihydroxybtanoic acid**.*



(2*R*,3*S*)-2,3-dihydroxybutanoic acid