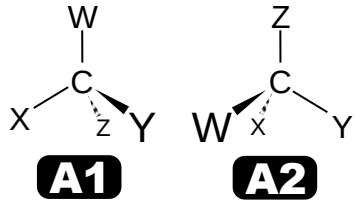
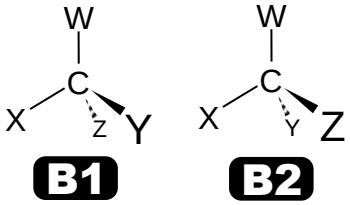
Organic Isomers 3:

R and S

If a carbon atom only has single bonds, they're sp^3 hybridized and the bonds have a tetrahedral arrangement—one bond pointing straight up, and the other three spread out pointing slightly downwards. The symmetry of that shape means that if those four bonds all lead to different structures, there are two different ways that those structures can be positioned around the atom, and no amount of rotation will turn one into the other.

Consider the molecules A1 and A2. They're the same molecule. If A1 were sitting on a table, we could tip it over by pulling W forward past X and Y until W falls on the table; Z lifts up. If you do this, you get A2.



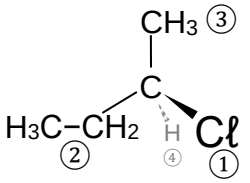


Now consider B1 and B2. The only change between them is that Y and Z have traded places; W and X are fixed, and that's why they're different molecules. We can't rotate B1 to get B2 because any rotation will move W and X. There's no way to keep W and X in place and swap Y and Z. It looks like B1 and B2 get the same name, but they are not the same molecule. The carbon atoms in the middle of these molecules are called **chiral centres**; the molecules themselves are **enantiomers**.

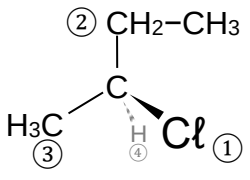
There are two instances where this difference can be detected. Polarized light that shines through samples of these chemicals have their angle of polarization turned, one clockwise and one counterclockwise by the same amount. (These isomers are also called **optical isomers**.) Additionally, the interactions of biological chemicals called enzymes happen so that they have to fit together in specific ways. The sizes of the structures that take the positions of WXYZ means that if one version of B1 or B2 fits, the other one won't. The molecules behave differently, physically and chemically.

We use the ***R*,*S* system** to distinguish and label enantiomers. We use the Cahn-Ingold-Prelog system to rank the four groups that are bonded to the chiral centre. They're numbered with #1 being top priority (highest atomic number) and #4 being the lowest priority (lowest atomic number). If the molecule is re-oriented so #4 faces away from you, as though you were holding that group in your hand like a microphone, then #1, #2, #3 will be arranged in a circle as you look down on it. If #1-2-3 goes clockwise, it's the ***R*** configuration, and if they go counterclockwise, it's the ***S*** configuration.

In these examples, the chloro group has top priority (Z = 17). Hydrogen has bottom priority (Z = 1). The other two are tied because the atom directly bonded to the chiral centre in both cases is carbon (Z = 6). We break the tie by looking at the other three bonds on the tied atoms. In the methyl group, those are three hydrogen atoms, but in the ethyl group, they're



(*R*)-2-chlorobutane



(*S*)-2-chlorobutane

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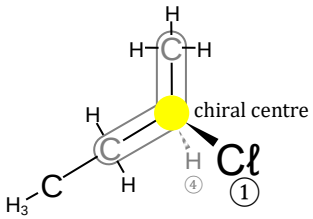
a carbon and two hydrogens. The ethyl group becomes #2 and the methyl group is #3. (For alkyl groups, therefore, longer chains get higher priority.)



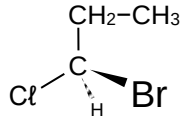
Then we look at the direction groups #1–3 are turning. The one on the left has them in order clockwise (the same way you'd turn a steering wheel *R*ight), so it's the *R* configuration. The other one goes counterclockwise and is the *S* configuration. The configuration is written before the compound's name, in parentheses, and separated by a hyphen from the rest of the name.

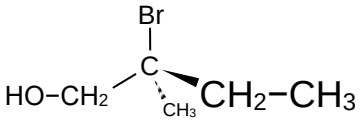
In these examples, #4 is conveniently drawn into the page. It can be hard to re-orient a three-dimensional object in your mind, but it can be learned. Another trick is that if have #4 pointing out of the page at you, and you go ahead anyway, you know the answer you get is wrong (*R* should be *S* and vice versa). You can also swap two groups to put #4 to the back, knowing that this reverses the configuration also.

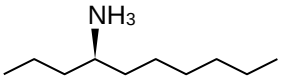
It's possible that a molecule has more than one chiral centre. Determine each centre's configuration separately, and report them all at the beginning, along with the number of the carbon atom within the parent chain: (2*S*,3*R*)-...

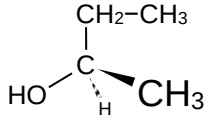
EXERCISES

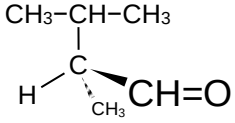
A. Name the following compounds, indicating chiral configuration where necessary.

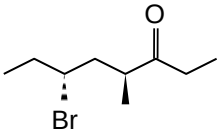
1) 

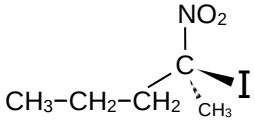
5) 

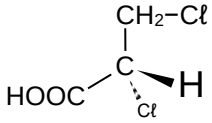
9) 

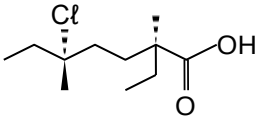
2) 

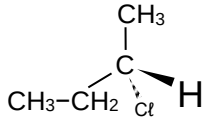
6) 

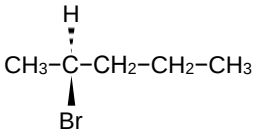
10) 

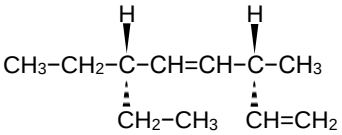
3) 

7) 

11) 

4) 

8) 

12) 

SOLUTIONS

A: (1) (*R*)-1-bromo-1-chloropropane (2) (*R*)-2-butanol (3) (*S*)-2-iodo-2-nitropentane (4) (*S*)-2-chlorobutane (5) (*S*)-2-bromo-2-methyl-1-butanol (6) (*R*)-2,3-dimethylbutanal (7) (*R*)-2,3-dichloropropanoic acid (8) (*S*)-2-bromopentane (9) (*R*)-1-propylheptanamine (10) (4*S*,6*R*)-6-bromo-4-methyl-3-octanone (11) (2*S*,5*S*)-5-chloro-2-ethyl-2,5-dimethylheptanoic acid (12) (*R*)-6-ethyl-3-methyl-1,4-octadiene