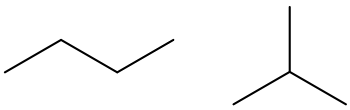
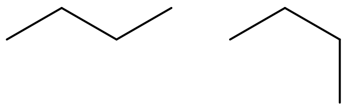
CHEM1611 Worksheet 11: Enantiomers and Diastereomers

Model 1: Isomerism

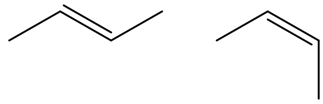
There are three broad classes of isomers.



Constitutional



Conformational



Configurational

- **Constitutional** isomers have the same formula but different connectivity.
- **Conformational** isomers differ only by rotation about a single bond. They interconvert freely at all but extremely low temperatures (ie they are identical).
- **Configurational** isomers (**stereoisomers**) have the same connectivity but cannot be interconverted through single bond rotation. Bond breaking and bond formation are required for interconversion.

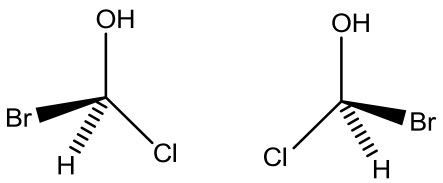
You may need a molecular model set for these activities.

Critical thinking questions

1. Draw two examples of configurational isomers, one involving a double bond and one involving a ring.

These are ***diastereomers***: they are not identical and they are not mirror images. Configurational isomers that are not identical but *are* mirror images are called ***enantiomers***.

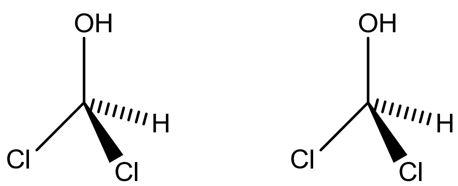
2. Using a model kit, construct the isomers below with a carbon at the centre (black) and 4 different coloured balls to represent the 4 groups bonded to it. Satisfy yourself and every member of your group that the two models are different (i.e. cannot be made the same just by being turned over).



3. On *one* model, swap two of the balls. What is the relationship between the two models now?

4. On *one* model, swap a second pair of balls. What is the relationship now?

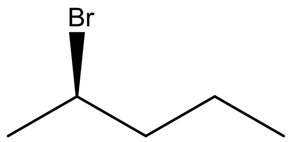
5. Make the models below and repeat these exercises. What do you notice?

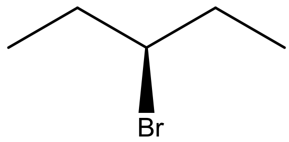


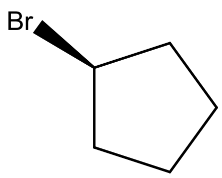
Spectroscopy Problem Solving Assignment - deadline is the end of week 12

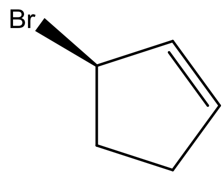
6. When a molecule can exist in 2 enantiomeric forms, it is said to be ***chiral***. From your experiments above, can you suggest a key requirement for molecules to be chiral?

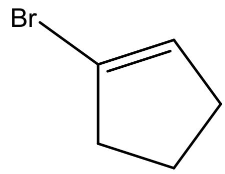
7. Identify the molecules below as chiral or achiral (= non-chiral).











The labels (*S*) & (*R*) are used to denote the stereochemistry for the two enantiomers of a chiral molecule.

To assign the a*bsolute stereochemistry*,

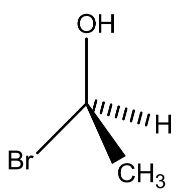
(i) Number the four substituents on the chiral centre in terms of priority (the same rules apply as for double bond isomers here)

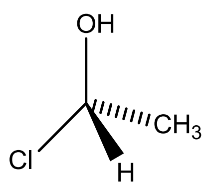
(ii) Draw the molecule with the *lowest priority group pointing into the page*.

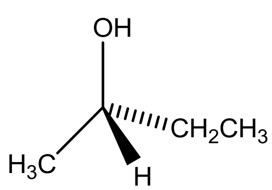
(iii) Count around the remaining groups from highest priority to lowest.

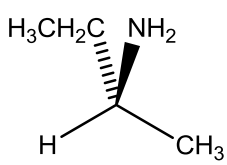
(iv) Assign the stereochemistry as (*R*) if these numbers are ordered clockwise and (*S*) if these numbers are ordered anti-clockwise.

8. Assign the absolute stereochemistry of the following molecules (some may need to be redrawn, use the model kit if you need to). Name them, including (*R*) or (*S*) at the beginning.









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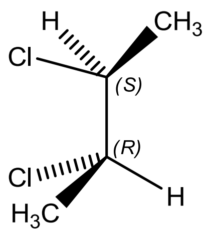
Things become more complex when the molecule contains a second (or third or fourth. …) chiral centre. One isomer of 2,3-dichlorobutane is shown below. It has two chiral centres with the absolute configurations shown.



9. Draw the other forms of 2,3-dichlorobutane in the space above.

10. Identify the relationships between *each pair*. *Hint:* they will either be enantiomers, diastereomers or the same. The pair that are the same as each other are not isomers – this is the ***meso form***.

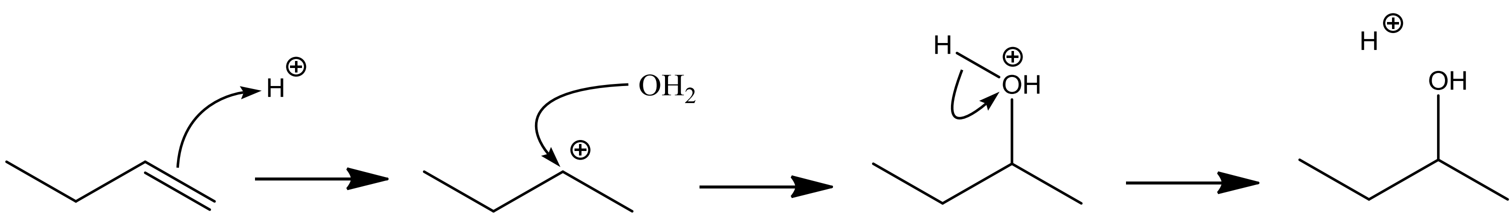
11. **Extension:** If you replace one of the chlorine groups with bromine and repeat the exercise, will you still get a pair of meso compounds? (Try to do this as a thought experiment first, then draw out the structures if you need to.)

Model 2: Stereochemistry and Reactions

Now that you are familiar with the different types of isomers, you can start looking at the stereochemical outcomes of the reactions that you have studied.

Critical thinking questions

1. Label the starting material, the carbocation intermediate and the product in the reaction below as chiral or achiral.

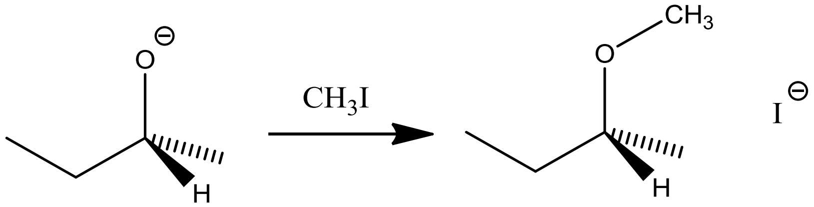


2. Imagine that water attacks the carbocation intermediate from *above* the plane of the page, draw the product and assign the stereochemistry. Repeat, this time imagining that water has attacked from *below*.

3. Which of these enantiomers do you think will actually be the product of this reaction?

Creating a chiral molecule from an achiral molecule generally leads to a 50:50 mixture of both enantiomers. **This is called a racemic mixture**.

4. The reaction below is an S_N2 reaction and leads to the formation of an ether. Do you expect the product to be (*R*), (*S*), a racemic mixture or achiral? Why?



5. **Extension:** The substitution reaction below goes *via* an S_N2 mechanism. Draw the product in 3D and assign the stereochemistry of both reactant and product.