

## CHEM1002 Worksheet 6: Elimination Reactions and Chirality

### Model 1: Enantiomers and Diastereomers

You will need a molecular model set for these activities.

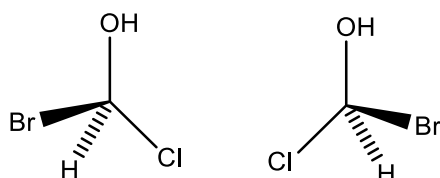
In Worksheet 2, you investigated constitutional, conformational and configuration isomers.

#### Critical thinking questions

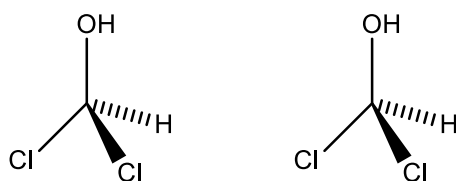
1. Draw two examples of configurational isomers, one involving a double bond and one involving a ring.

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*.

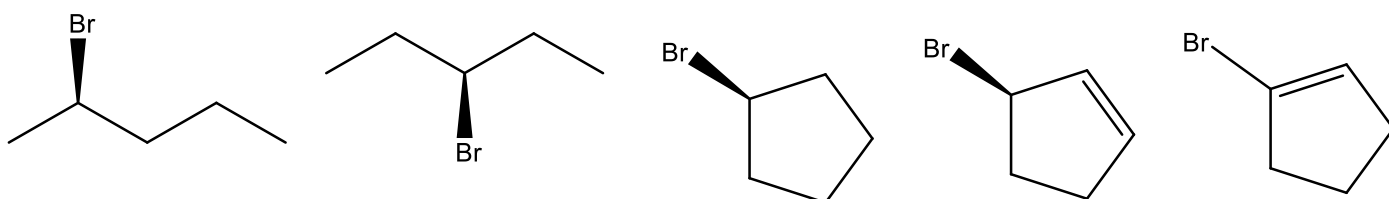
2. Using a model kits, construct the isomers below with a carbon at the centre (black) and 4 different coloured balls to represent the 4 groups bonded to it. Satisfy yourself and every member of your group that the two models are different (i.e. cannot be made the same just by being turned over).



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?



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).

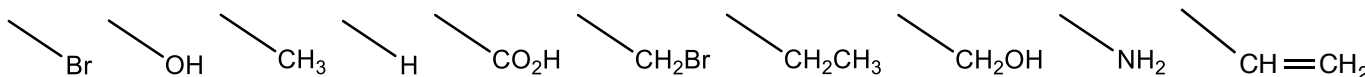


Just as (*E*) & (*Z*) and *cis* & *trans* are used to distinguish between diastereomers, (*S*) & (*R*) are used to denote the stereochemistry for the two enantiomers of a chiral molecule.

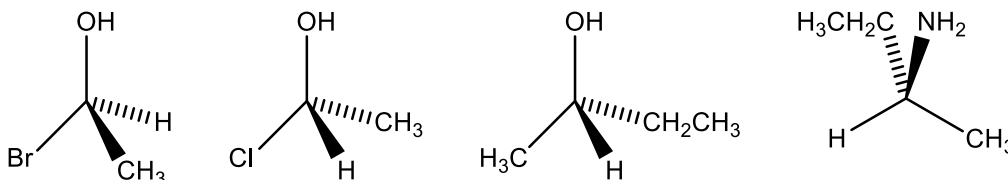
To assign the *absolute stereochemistry*,

- Number the four substituents on the chiral centre in terms of priority (the same rules apply as for double bond isomers here)
- Draw the molecule with the *lowest priority group pointing into the page*
- Count around the remaining groups from highest priority to lowest:
- Assign the stereochemistry as (*R*) if these numbers are ordered clockwise and (*S*) if these numbers are ordered anti-clockwise.

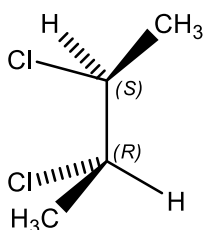
8. Rank the following 10 groups in order of increasing priority (1 = lowest, 10 = highest).



9. 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.



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.

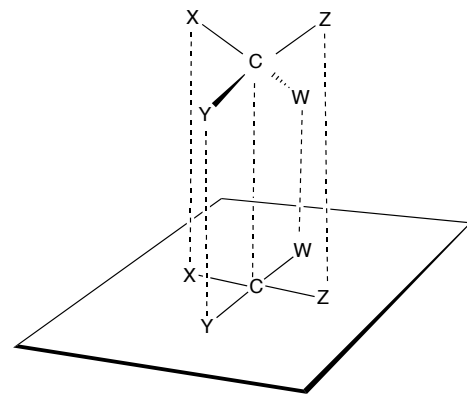


- Draw the other forms of 2,3-dichlorobutane in the space above.
- Identify the relationships between *each pair*. *Hint*: they will either be enantiomers, diastereomers or the same. The pair that are the same as each other are not isomers – this is the *meso form*.

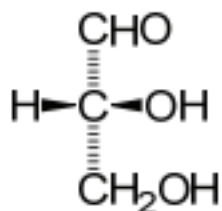
## Model 2: Fischer Projections

Fischer projections are used to simplify drawing chiral molecules. They show a 2-dimensional representation of the 3-dimensional molecule, as shown on the picture on the right. To construct a Fischer projection:

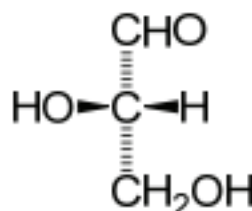
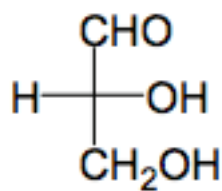
- arrange the atoms of the carbon skeleton in a vertical line with the most oxidized functional group at the top
- horizontal lines represent substituents on the chiral carbon atom(s)
- **horizontal** lines represent bonds pointing *upwards* and
- **vertical** lines represent bonds pointing *downwards*.



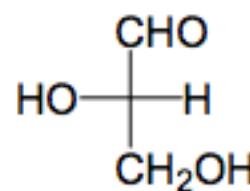
The Fischer projections of the two enantiomers of glyceraldehyde are shown below to illustrate this.



(R)=(+)-glyceraldehyde

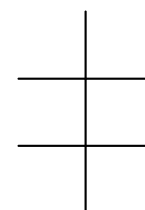
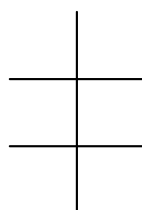
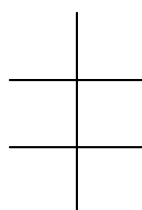
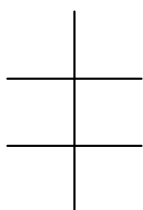
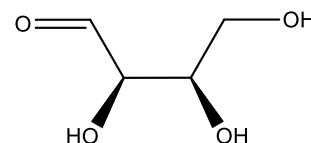
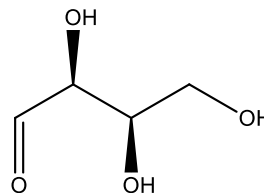
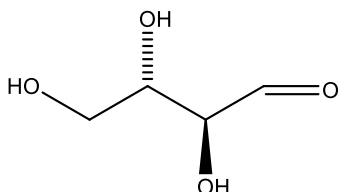
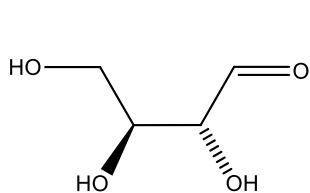


(S)=(-)-glyceraldehyde



## Critical thinking questions

1. Draw each of the following aldotetrose structures as Fischer projections. Describe the relationships between the structures (enantiomers, diastereomers, or same compound).



2. What advantages can you see in Fischer representations?

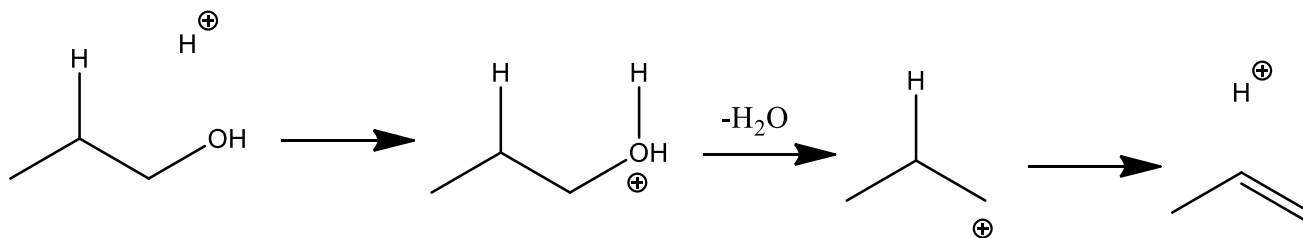
## Model 3: Elimination Reactions

In Worksheet 3, you saw how the C=C bonds undergo electrophilic addition reactions in which a group is added to each end of the double bond and the  $\pi$  bond is lost. Elimination reactions are the opposite: a group is lost from each end of a C-C bond to form a C=C double bond. *Hydration* is a special example of addition: H is added to one end and OH added to the other of the C=C bond. *Dehydration* is the opposite and is a

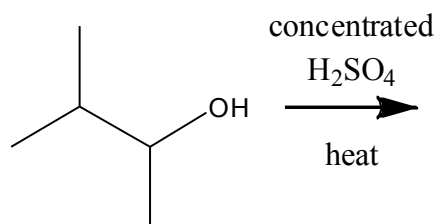
special example of elimination: H is removed from one end and OH removed from the other end of the C-C bond.

### Critical thinking questions

1. Complete the mechanism for the dehydration of water from 1-propanol to form propene by adding curly arrows.



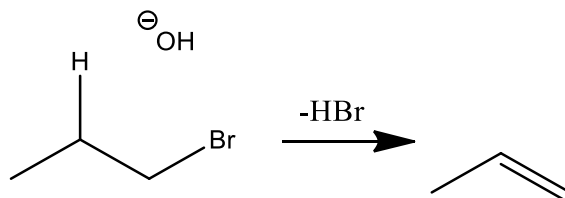
2. The first step involves protonation of the alcohol. Why is this step necessary?
3. What is the overall role of  $\text{H}^+$  in the reaction?
4. There are two possible alkenes formed in the elimination reaction below. Draw both.



5. *More* substituted alkenes are *more* stable. Indicate the likely *major* and *minor* products in Q4.

**This is an example of Zaitsev's rule: the major product of an elimination reaction will be the more substituted alkene**

The acid-catalysed dehydration reaction in Model 1 is a common way to make alkenes. A second way is through base-catalysed elimination:



This is an example of an E2 reaction whereas the acid-catalysed elimination in Model 2 is an E1 reaction.

6. Complete the mechanism by adding curly arrows.