ORGANIC CHEMISTRY I

STEREOCHEMISTRY EXERCISES – SET 2

PART A

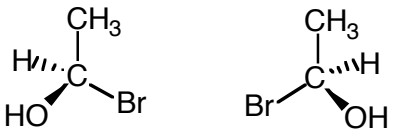
Consider the following molecules and answer the questions.

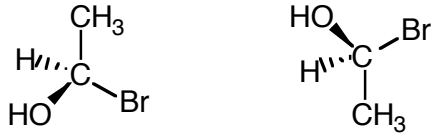
a) dichloromethane
b) 1-bromo-1-chloroethane
c) 2-bromopropane
d) 2-chlorobutane
e) *cis*-1,2-dichlorocyclopropane
f) *trans*-1,2-dichlorocyclopropane
g) *trans*-1-bromo-3-chlorocyclobutane
h) *trans*-1-bromo-2-chlorocyclobutane
i) *cis*-1-bromo-2-chloroethene
j) *trans*-1-bromo-2-chloroethene
k) (2S, 3R)-2,3-dibromobutane
l) (2R, 3R)-2,3-dibromobutane
m) *meso*-1,3-dimethylcyclohexane

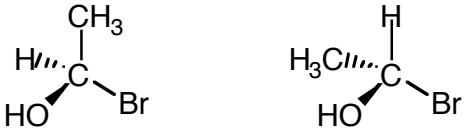
1. Which of these molecules are chiral (i.e. asymmetric)?
2. Which of these molecules contain chiral carbons? In your drawings label them with an asterisk.
3. Which of these molecules can exist as enantiomeric pairs?
4. Which of these molecules represent *meso* compounds?

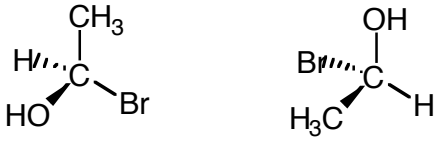
PART B

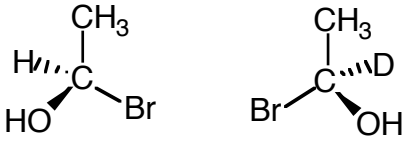
Indicate whether the following pairs of compounds represent the same molecule, pairs of enantiomers, diastereomers, meso compounds, or stereochemically unrelated molecules.

a) 

b) 

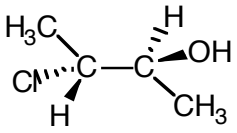
c) 

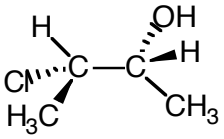
d) 

e) 

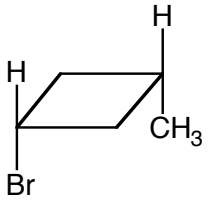
f) 

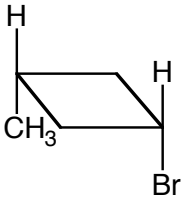
g)


H3C
H
OH
Cl
C
C
H
CH3

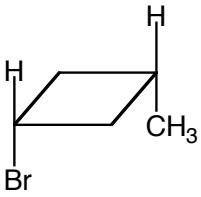

H
OH
Cl
C
C
H
H3C
CH3

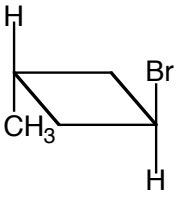
h)


H
H
CH3
Br

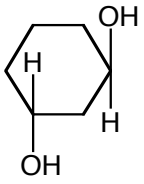

H
H
CH3
Br

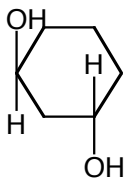
i)


H
H
CH3
Br

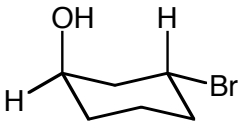

H
Br
CH3
H

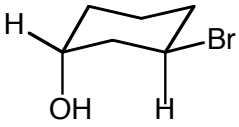
j)


OH
H
H
OH

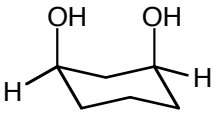

OH
H
H
OH

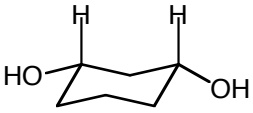
k)


OH
H
H
Br

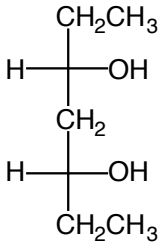

H
Br
OH
H

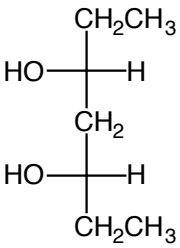
l)


OH
OH
H
H

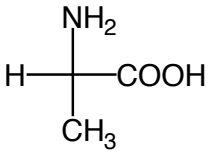

H
H
HO
OH

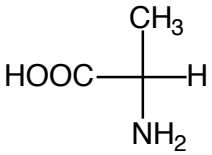
m)


CH2CH3
H
OH
CH2
H
OH
CH2CH3

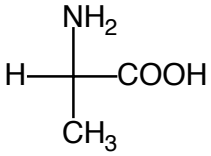

CH2CH3
HO
H
CH2
HO
H
CH2CH3

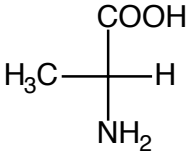
n)


NH2
H
COOH
CH3

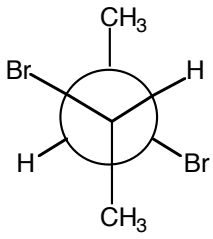

CH3
HOOC
H
NH2

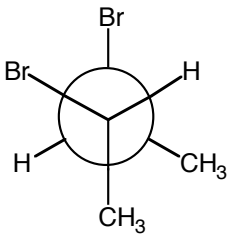
o)


NH2
H
COOH
CH3


COOH
H3C
H
NH2

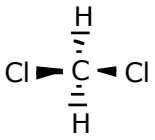
p)


CH3
Br
H
H
Br
CH3

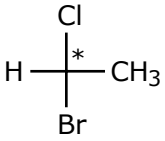

Br
Br
H
H
CH3
CH3

ANSWERS TO STEREOCHEMISTRY EXERCISE

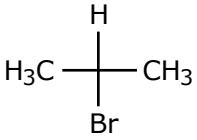
PART A - Molecules (a) through (m) below have been drawn in a way that makes their symmetry apparent if they are in fact symmetric. All the molecules labeled chiral can exist as enantiomeric pairs. All molecules with two chiral carbons and a plane of symmetry represent meso compounds, namely (e), (k), and (m). Chiral carbons have been marked with an asterisk.



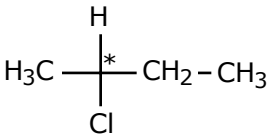
dichloromethane
achiral



1-bromo-1-chloroethane
one chiral carbon
chiral



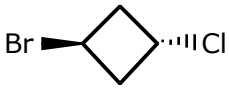
2-bromopropane
achiral



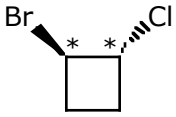
2-chlorobutane
one chiral carbon
chiral

cis-1,2-dichloro-
cyclopropane
2 chiral carbons
achiral

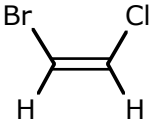
trans-1,2-dichloro-
cyclopropane
2 chiral carbons
chiral



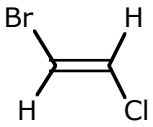
trans-1-bromo-3-chloro-
cyclobutane
achiral



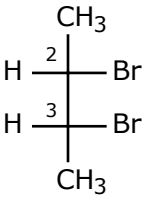
trans-1-bromo-2-chloro-
cyclobutane
2 chiral carbons
chiral



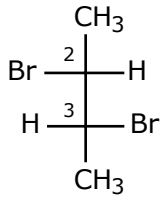
cis-1-bromo-2-chloro-
ethene
achiral (planar)



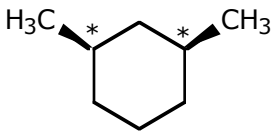
trans-1-bromo-2-chloro-
ethene
achiral (planar)



(*2S,3R*)-2,3-dibromo-
butane
2 chiral carbons
achiral



(*2R,3R*)-2,3-dibromo-
butane
2 chiral carbons
chiral



meso-1,3-dimethyl-
cyclohexane
2 chiral carbons
achiral

PART B - Before assigning configuration to carbons, **make sure they are chiral!**

a) Chiral molecule and its mirror image - **enantiomers**.

b) *R*-isomer on the left, *S*-isomer on the right - **enantiomers**.

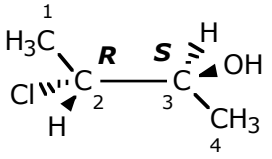
c) ***-OH*** and ***-Br*** are in the same positions, but ***-H*** and ***-CH_3*** have been exchanged - **enantiomers**.

d) *R*-isomer on the left, *R*-isomer on the right - **same molecule**.

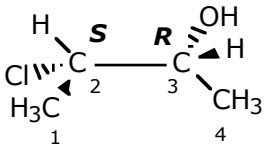
e) Both molecules are chiral, but they do not have the same groups attached to the chiral carbon - **unrelated**.

f) Each molecule is chiral (no plane of symmetry) and they are mirror images - **enantiomers**.

g) The easiest way to approach this one is to assign configurations to the chiral carbons. The molecules have the same molecular formula and the same connectivities, but their 3D arrangement is different. They are stereoisomers. The configurations of their chiral centers mirror each other, which makes them **enantiomers**.

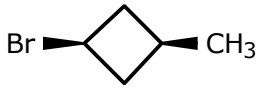


(*2R, 3S*)



(*2S, 3R*)

h) The molecule is not chiral (easiest to see in top view) and they're both *cis*-isomers - **same molecule**.

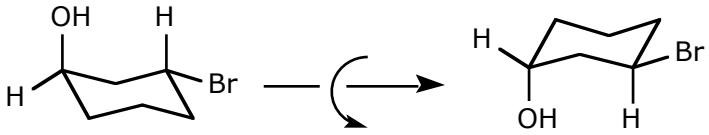


cis-1-bromo-3-methylcyclobutane

i) A pair of *cis/trans* isomers - **diastereomers**.

j) Two *trans*-isomers (chiral) and mirror images - **enantiomers**.

k) Rotating the molecule on the left as shown leads to the molecule on the right - **same molecule**.



l) *Cis*-isomers, same substituents on the same carbons (1 and 3), but different conformations - **same molecule**.

m) Each molecule has two chiral carbons and a plane of symmetry. Although they mirror each other, the are the **same molecule** (a *meso* compound).

n) Both structures represent the *S*-isomer - **same molecule**.

o) *S*-isomer on the left, *R*-isomer on the right - **enantiomers**.

p) Both molecules represent 2,3-dibromobutane, but the molecule on the left has all the groups (***-H***, ***-Br***, ***-CH_3***) *anti* to each other. One can rotate the front carbon until all the groups eclipse and match each other.
That is not the case with the molecule on the right. Both molecules have two chiral carbons. The one on the left has a plane of symmetry, which makes it a *meso* compound. The molecule on the right has no symmetry and therefore it is chiral. They are **diastereomers**. For added clarity turn the molecules around to view them from the side.