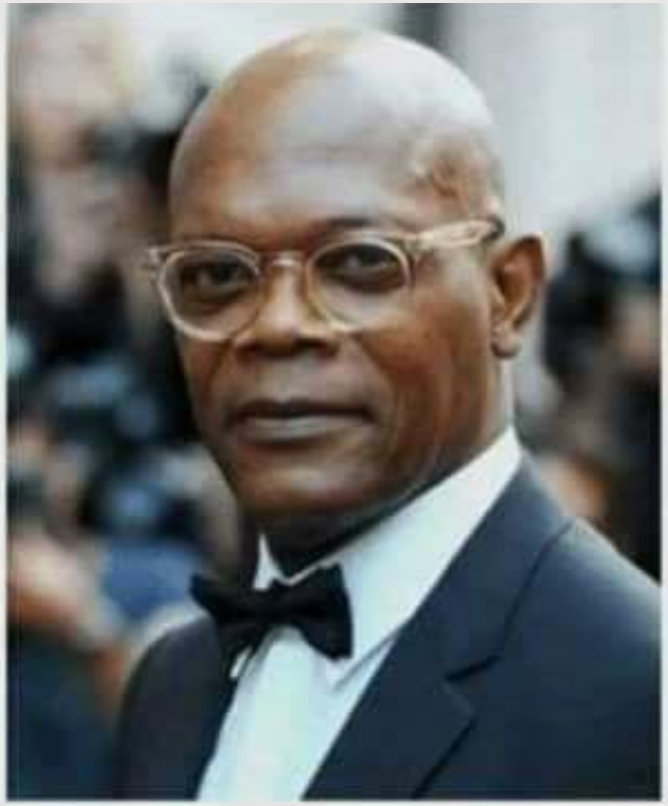
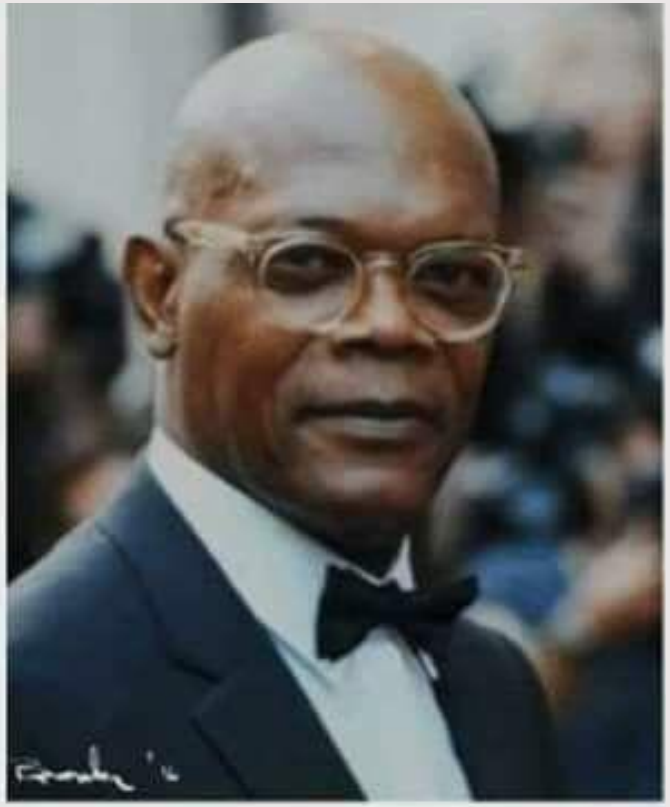


Samuel-**L**-Jackson

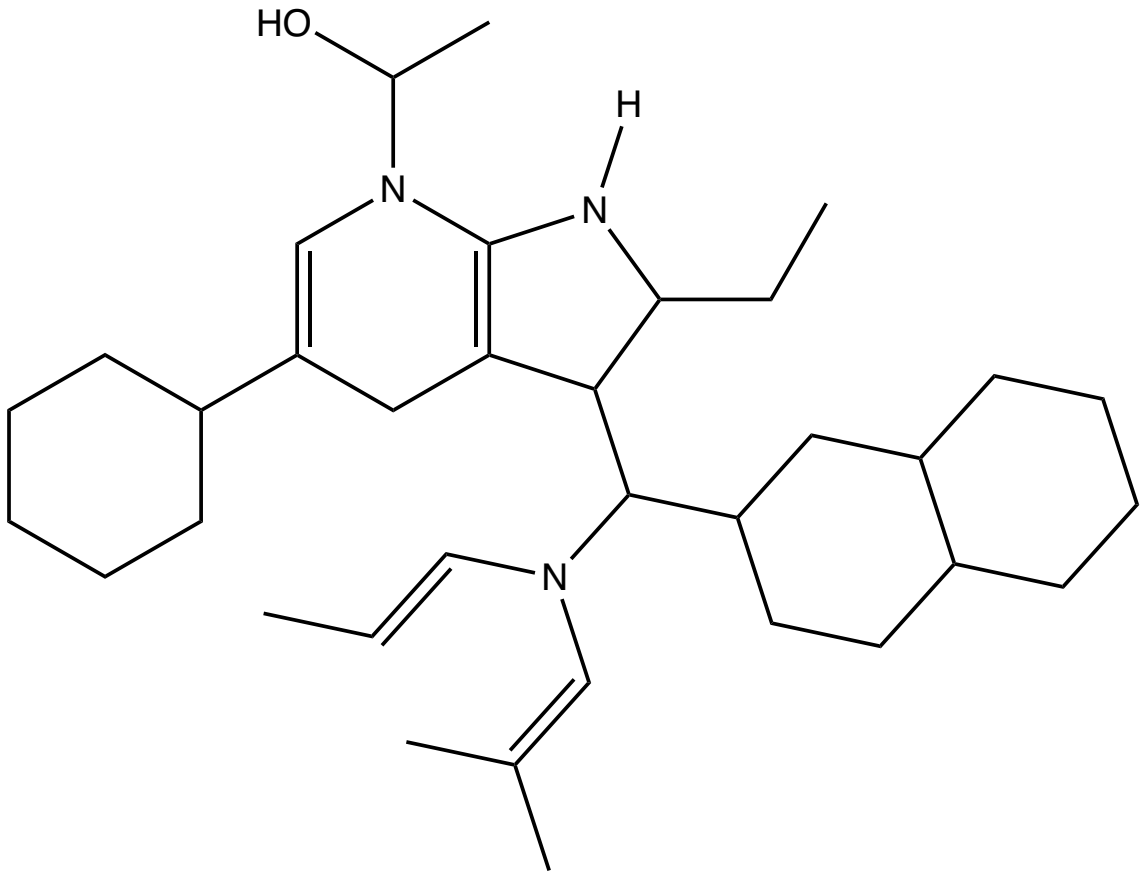


Samuel-**D**-Jackson

CH. 5 STEREOCHEMISTRY

1

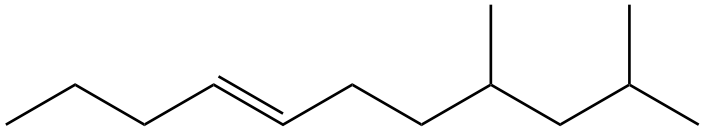
Identify the stereocenters on this molecule. How many stereoisomers are possible?



2

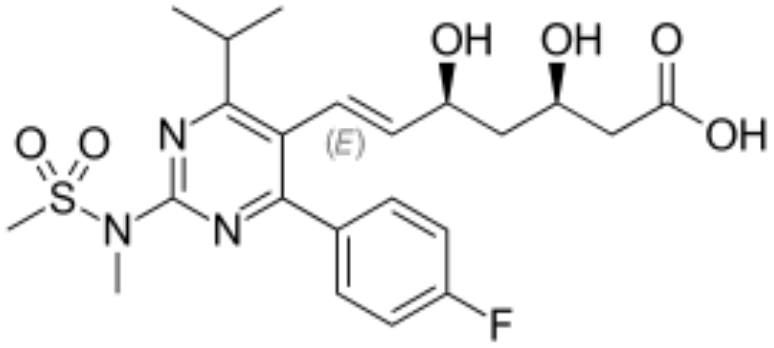
How many stereoisomers are possible for each of the following compounds?

a)

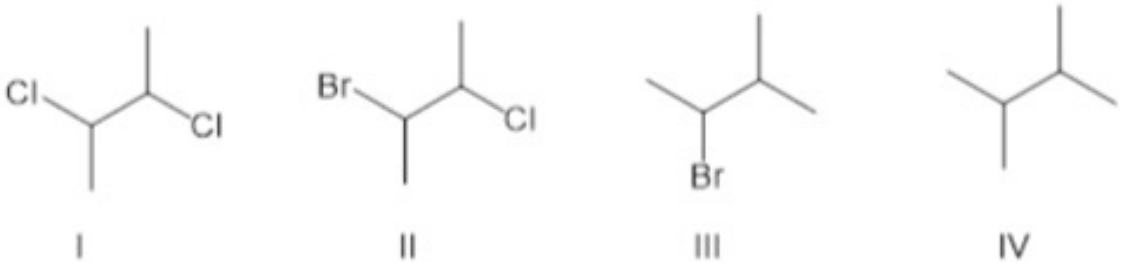


b) $BrCH_2CHClCH_2CHClCH_2Br$

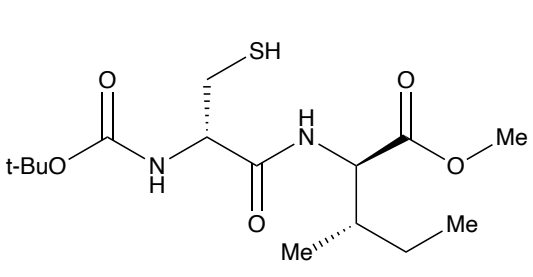
c)

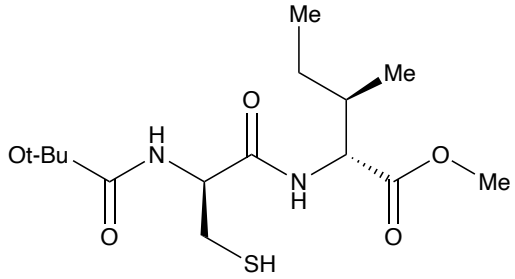


Which of the following can be a *meso* isomer?



Which of the relationship between the two molecules?



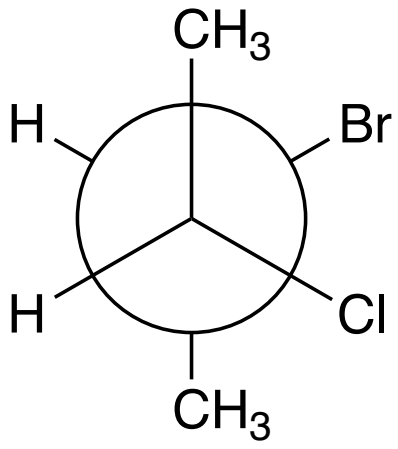


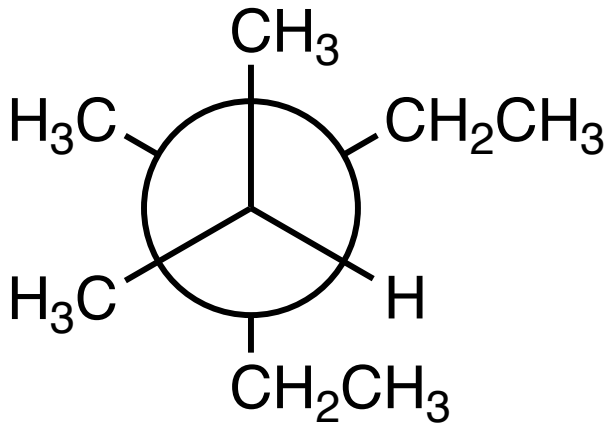
a) Enantiomers
b) diastereomers
c) conformers

d) *meso*-identical
e) identical

3

Draw wedge-dash structures for the following Newman projections. Are the following compounds chiral? If so, identify the chiral centers as either *R* or *S* .





4

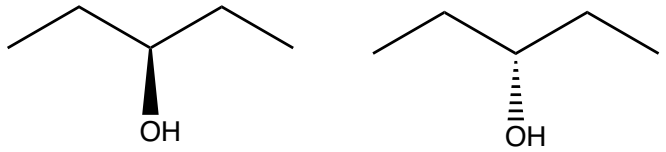
Draw all possible stereoisomers for **3,4-dichlorohexane**. Label R/S and indicate which pairs are enantiomers. If any of the stereoisomers are optically inactive, circle them and briefly explain why.

Draw all possible stereoisomers for **1,4-dimethylcyclohexane**. How many stereoisomers are there? Is either chiral? If not, what makes them stereoisomers?

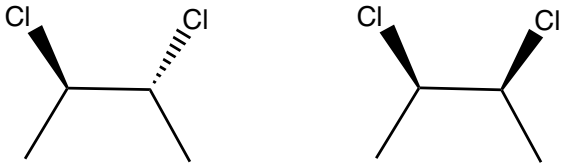
5

What is the relationship between the two compounds: identical, meso-identical, enantiomers, diastereomers?

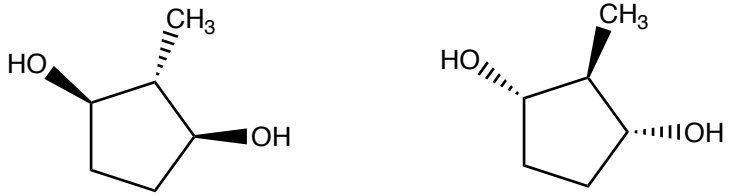
a)



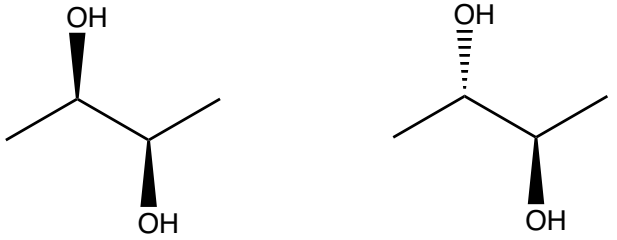
b)



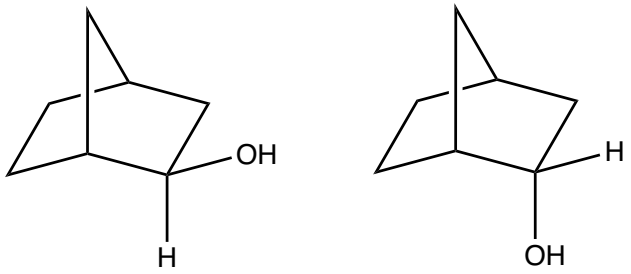
c)



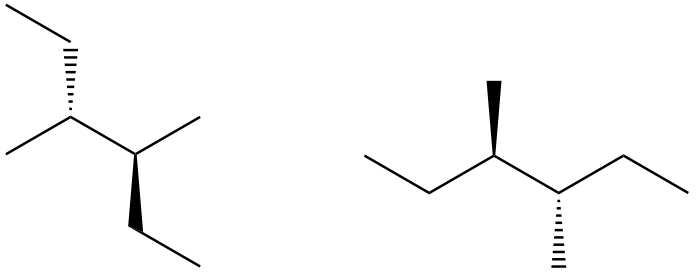
d)



e)



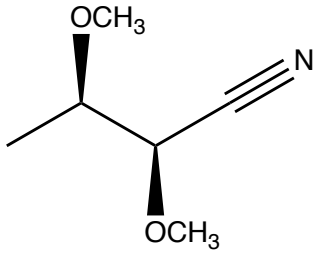
f)

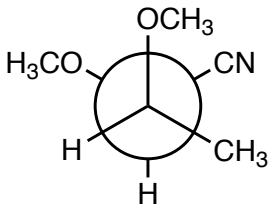


6

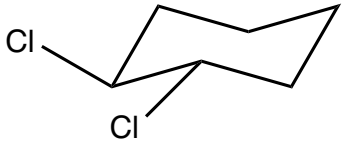
What is the relationship between the two compounds: identical, meso-identical, enantiomers, diastereomers?

a)



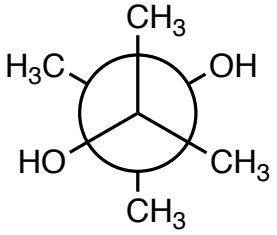


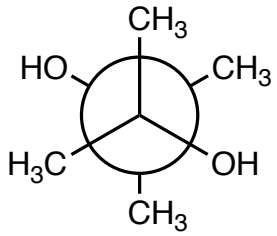
b)



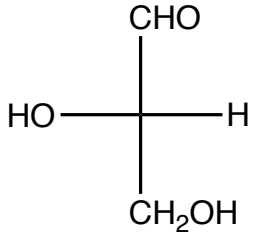


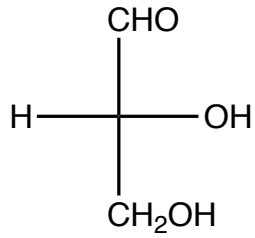
c)



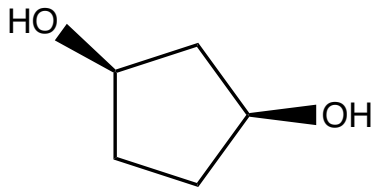


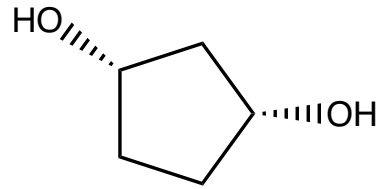
d)



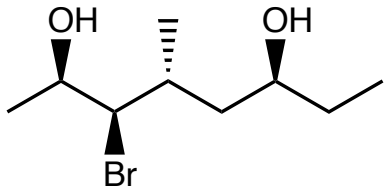


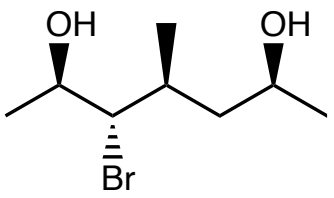
e)



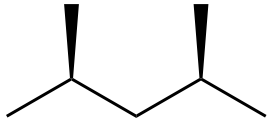


f)

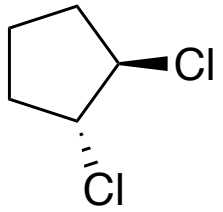




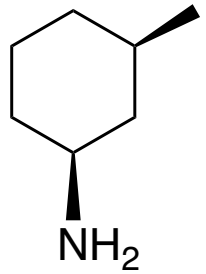
7 Is the compound chiral (C), achiral (A), or meso-achiral (M)? If appropriate, assign R/S stereochemistry.



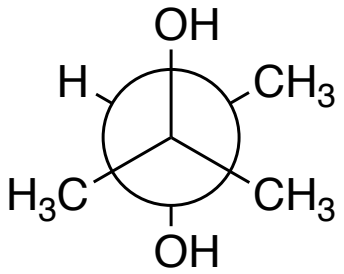
a) ☐



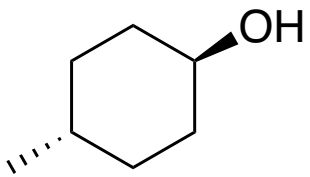
b) ☐



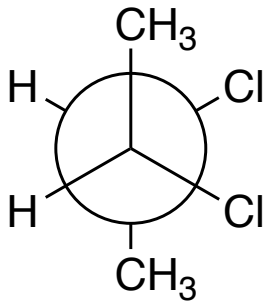
c) ☐



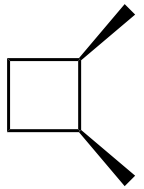
d) ☐



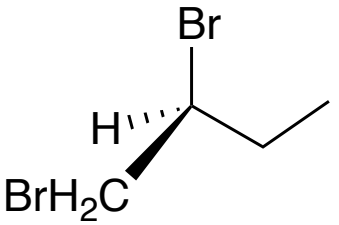
e) ☐



f) ☐

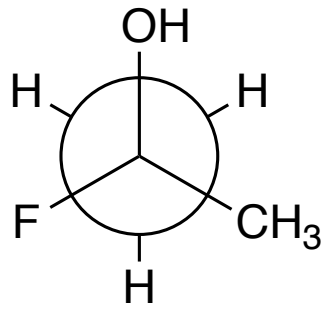


g) ☐

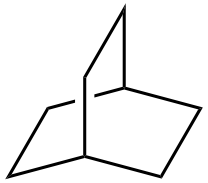


h) ☐

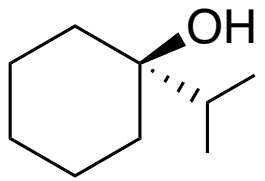
8 Is the compound chiral (C), achiral (A), or meso-achiral (M)? If appropriate, assign R/S stereochemistry.



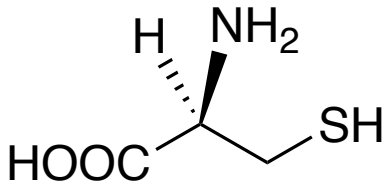
a) ☐



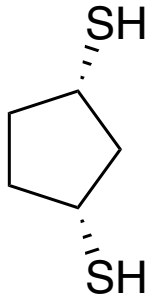
b) ☐



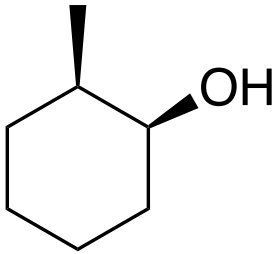
c) ☐



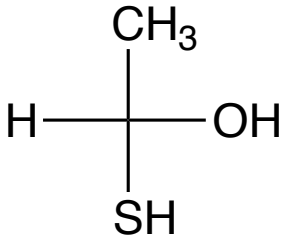
d) ☐



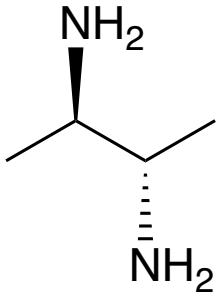
e) ☐



f) ☐



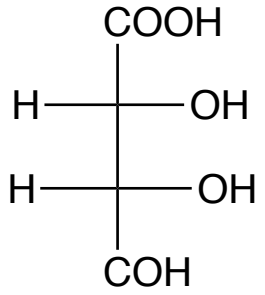
g) ☐

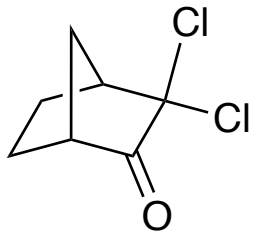


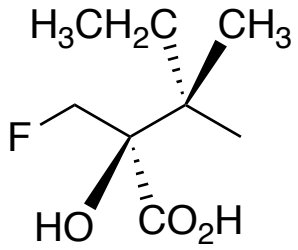
h) ☐

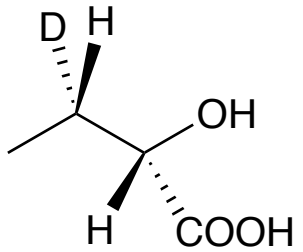
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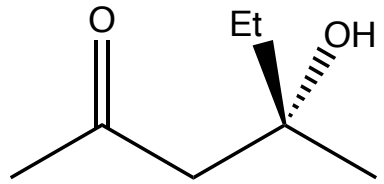
Is the compound chiral (C), achiral (A), or meso-achiral (M)? If appropriate, assign R/S stereochemistry.











10

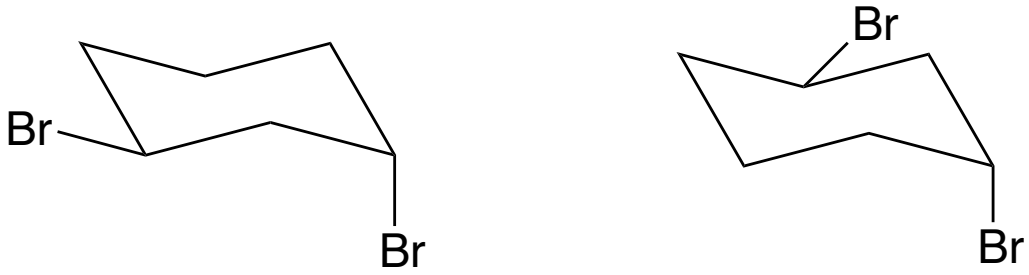
The two compounds are:

A. identical

B. enantiomers

C. diastereomers

D. conformational isomers



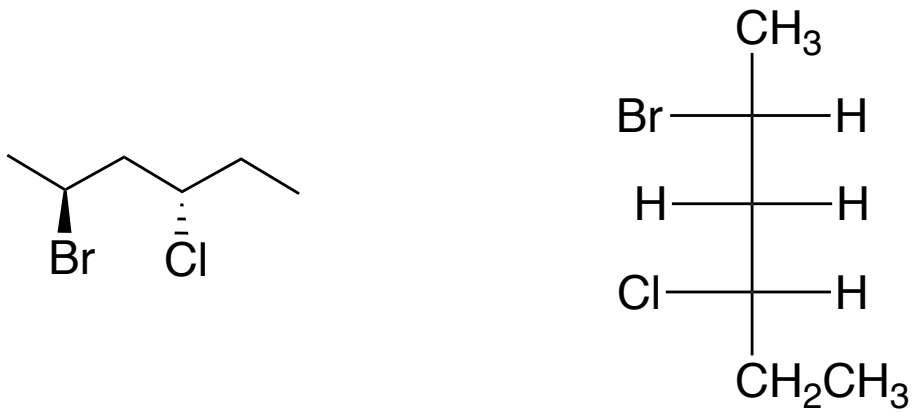
The two compounds are:

A. Identical

B. enantiomers

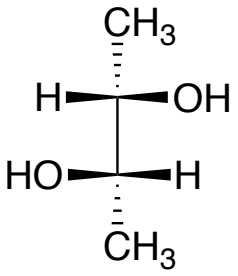
C. diastereomers

D. conformational isomers

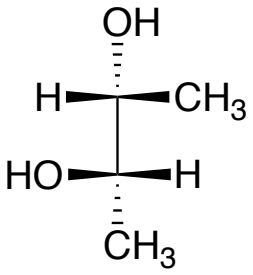


11

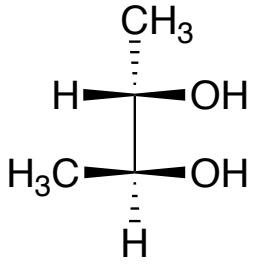
Which of the following compound(s) represent(s) *meso*-2,3-butanediol?



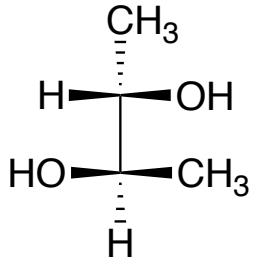
I.



II.

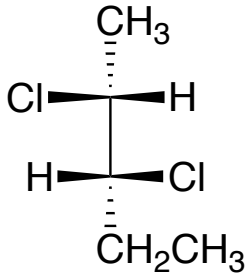


III.

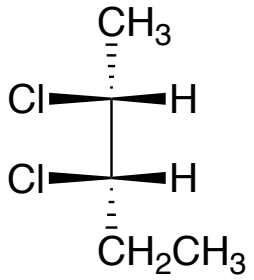


IV.

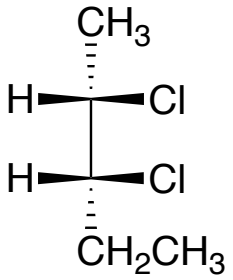
Which of the following compound(s) represent(s) (*S,S*)-2,3-dichloropentane?



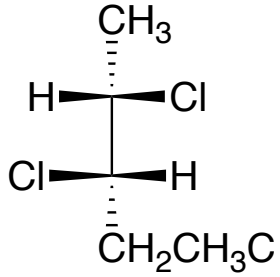
I.



II.



III.



IV.

12

A sample of 2-bromobutane has an enantiomeric excess (e.e.) of 75% favoring the *d*–enantiomer. What is the percentage of each enantiomer?

A. 87.5 % (–) enantiomer, 12.5% (+) enantiomer

B. 75% (+) enantiomer, 25% (–) enantiomer

C. 75% (–) enantiomer, 25% (+) enantiomer

D. 87.5% (+) enantiomer, 12.5% (–) enantiomer

A mixture of enantiomers of tartaric acid that has an observed rotation of +6°. Optically pure *l*-tartaric acid has a specific rotation of –12°. What is the percent composition of each the *l* and *d* enantiomers?

A. 50% (+) enantiomer, 50% (–) enantiomer

B. 75% (+) enantiomer, 25% (–) enantiomer

C. 25% (+) enantiomer, 75% (–) enantiomer

D. 60% (+) enantiomer, 40% (–) enantiomer

E. 40% (+) enantiomer, 60% (+) enantiomer

13

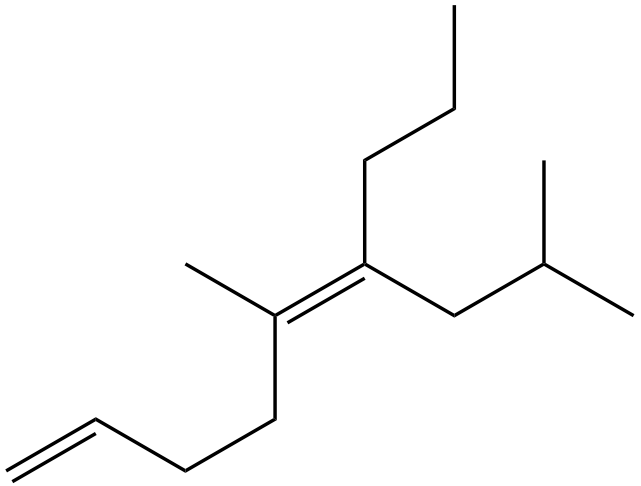
The specific rotation of (S)-butanol is +13.5. If 1.00 g of **its enantiomer** is dissolved in 10.0 mL of ethanol and placed in a sample cell with a length of 1.0 dm, what observed rotation would you expect?

$$\text{Specific rotation} = [\alpha] = \frac{\alpha}{c \times l}$$

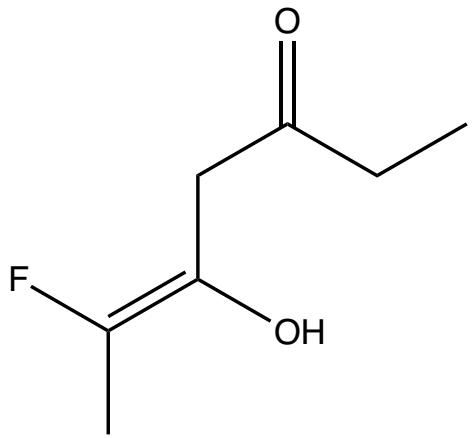


14 Identify the configurations of the following alkenes as E or Z.

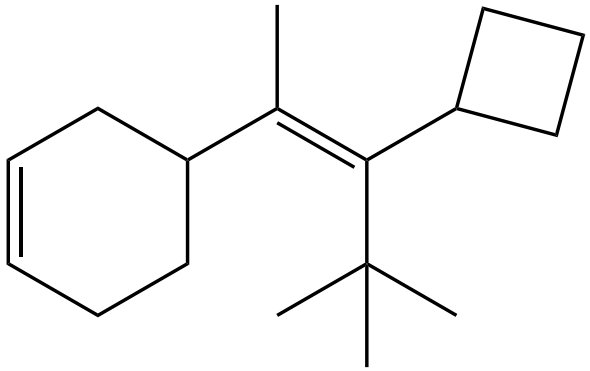
a)



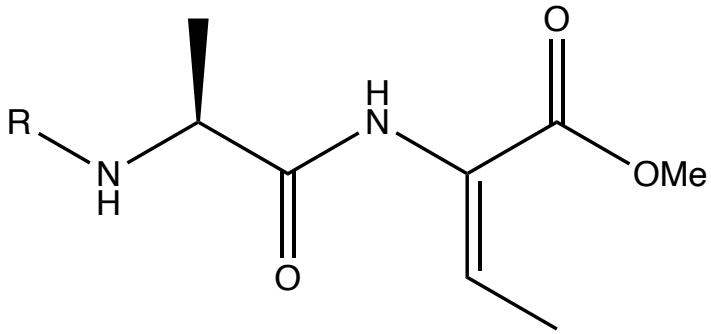
b)



c)



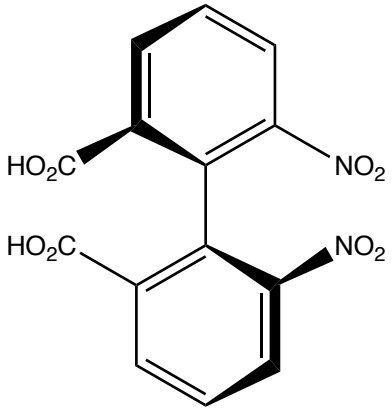
d)



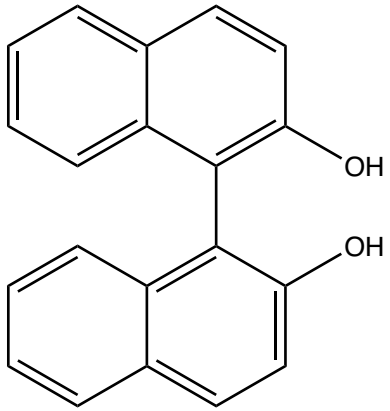
15

Atropisomers & **Allenes**: Which of the following compounds is/are chiral?

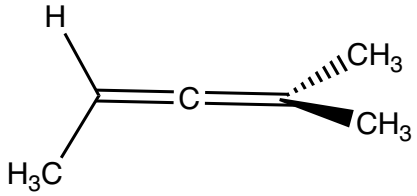
a)



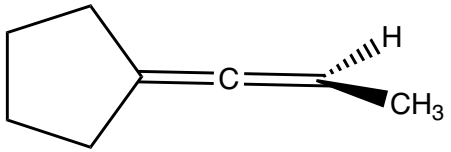
b)



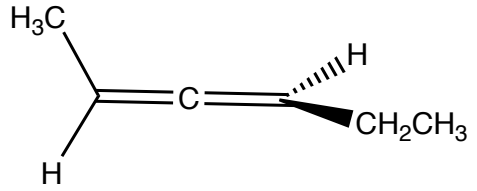
c)



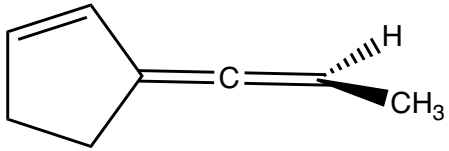
d)



e)



f)



ANSWER KEY

1

Identify the stereocenters on this molecule. How many stereoisomers are possible?

HYBRIDIZATION

Only sp^3-carbons can be chiral.

sp^2 or sp carbons ***cannot*** be chiral.

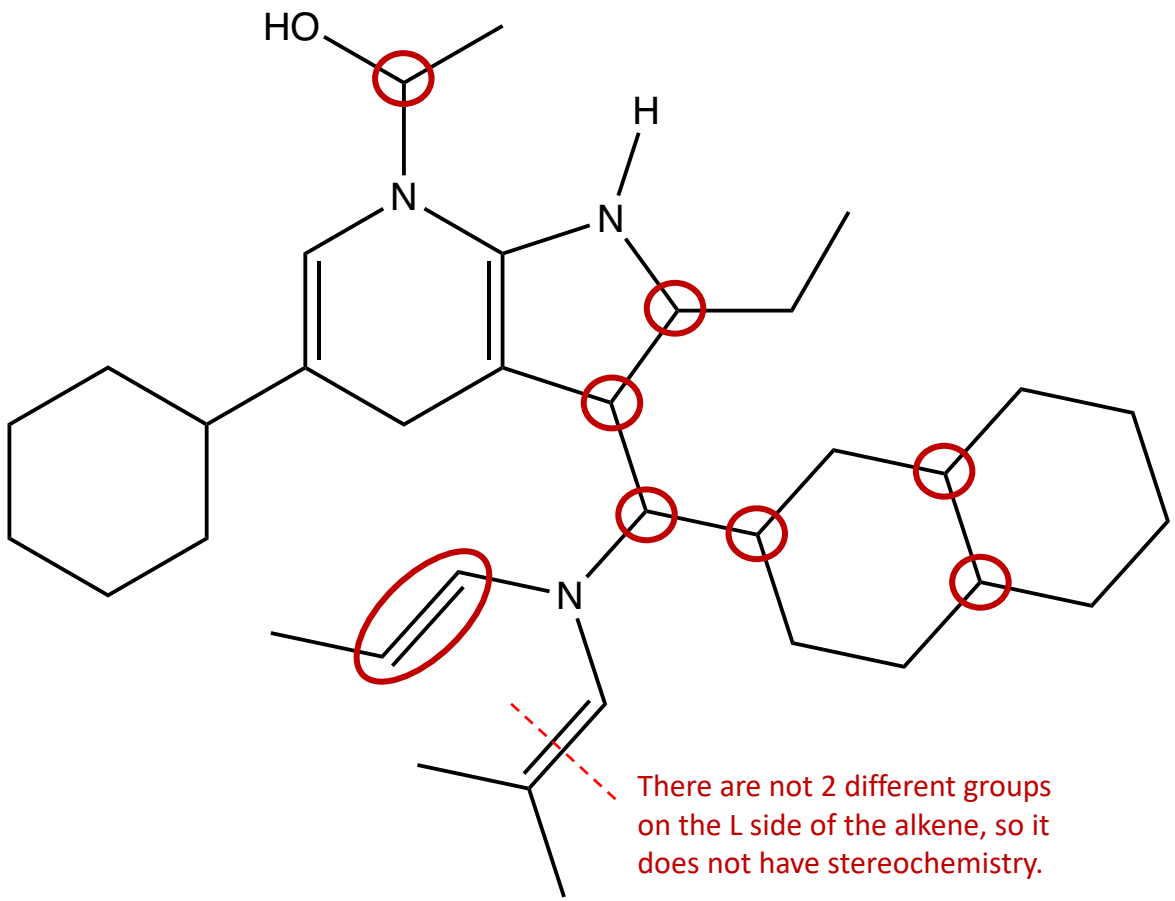
* exceptions are allenes (see 5.10)

DOUBLE BONDS

- Alkenes can be either *E*/*Z*
- Alkenes in rings do *not* count as stereocenters because they are locked into a particular configuration.
- Alkenes that do *not* have unique groups on both sides can*not* be stereocenters.

NITROGEN

N atoms, due to their trigonal pyramidal geometry and lone pair ***cannot*** be chirality.

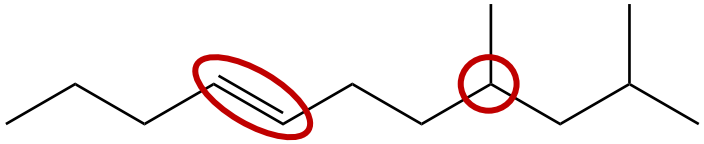


Number of stereoisomers: $2^n = 2^8 =$ **256**

2

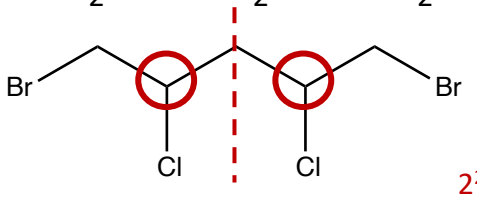
How many stereoisomers are possible for each of the following compounds?

a)



2^2 = **4 stereoisomers**

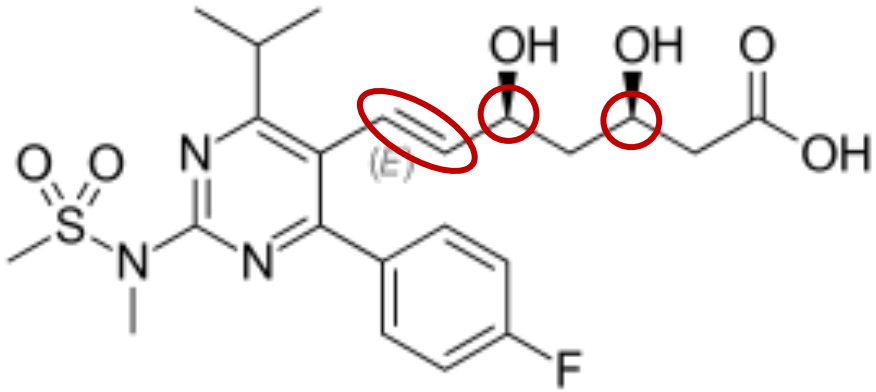
b) $BrCH_2CHClCH_2CHClCH_2Br$



Internal plane of symmetry

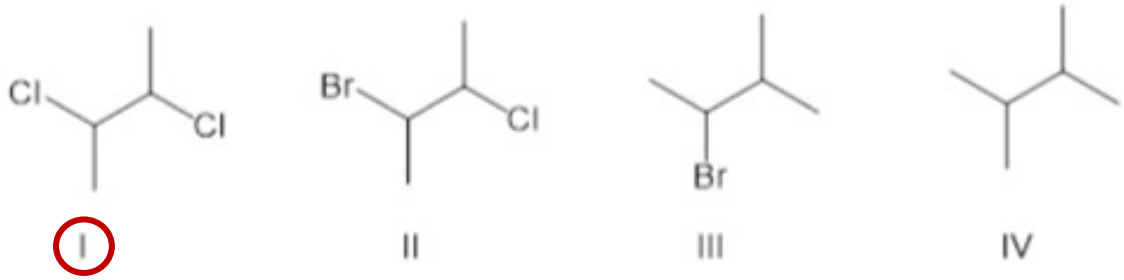
2^2 = 4 stereoisomers
– 1 *meso* compound
3 stereoisomers

c)



2^3 = **8 stereoisomers**

Which of the following can be a *meso* isomer?

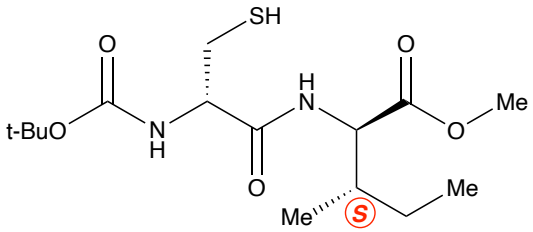


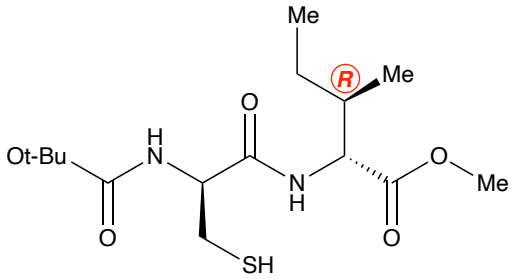
A *meso* compound must have:

- a plane of symmetry
- chiral centers (R,S or S,R)

II and III do not have an internal plane of symmetry.
IV does not have any chiral centers.

Which of the relationship between the two molecules?



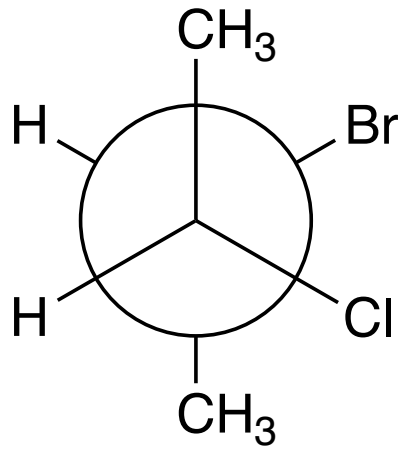


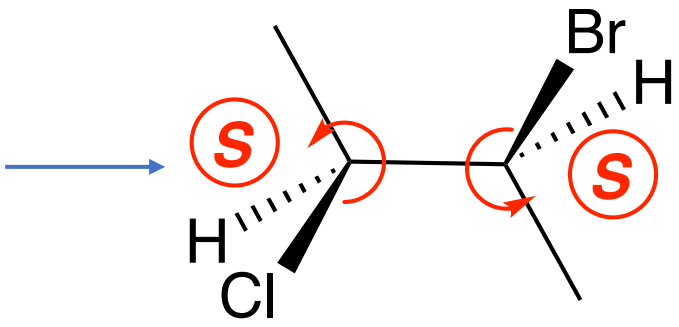
a) Enantiomers
b) diastereomers
c) conformers
d) *meso*-identical
e) identical

All other chiral centers have the same absolute configuration except the one identified. *Note*: The molecule is just flipped 180° along the x-axis.

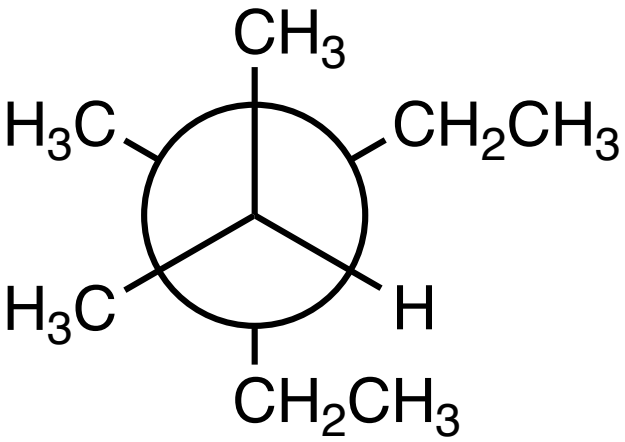
2

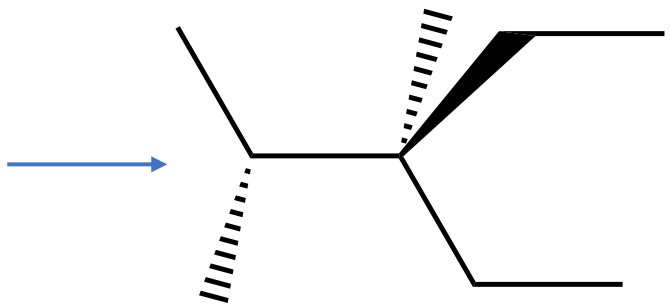
Draw a wedge-dash perspective of the following Newman projections. Are the following compounds chiral? If chiral, identify the chiral centers as either *R* or *S* .





chiral

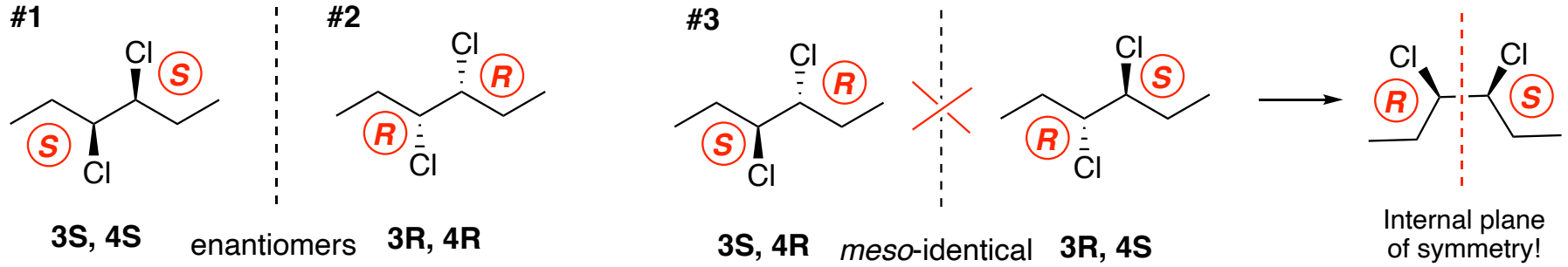




achiral

4

Draw all possible stereoisomers for **3,4-dichlorohexane**. Label R/S and indicate which pairs are enantiomers. If any of the stereoisomers are optically inactive, circle them and briefly explain why.



3S, 4S enantiomers **3R, 4R**

3S, 4R *meso*-identical **3R, 4S**

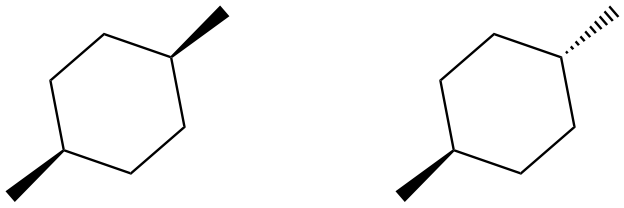
Internal plane of symmetry!

There are only 3 stereoisomers.

(3S,4R)-3,4-dichlorohexane is a meso compound (notice that its "enantiomer" is actually the same compound), thus it is optically inactive. The **net** optic **in**activity is due to the optic activity of one chiral center cancelling out the optic activity of the other.

Struggling with identifying *Meso* compounds?
Read "The Meso Trap"

Draw all possible stereoisomers for **1,4-dimethylcyclohexane**. How many stereoisomers are there? Is either chiral? If not, what makes them stereoisomers?



cis ***trans***

There are only 2 stereoisomers.

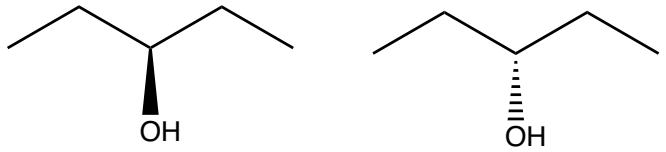
Neither of these compound is chiral. Because C_1 and C_4 do not have 4 unique groups—the R groups on either side of the ring are equivalent—neither of these stereocenters is chiral. C_1 and C_4 are *only* considered stereocenters because the substituents can be *cis* or *trans*. However, because both are achiral, neither has an enantiomer.

Note: These are *not* meso compounds because there are no chiral centers.

5

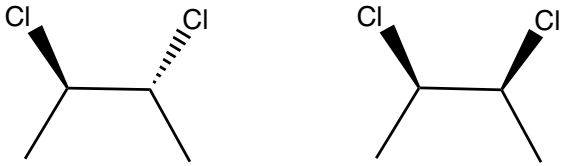
What is the relationship between the two compounds: identical, enantiomers, diastereomers?

a)



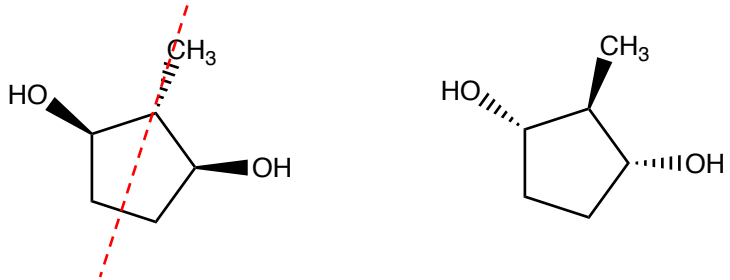
Identical; there are no chiral centers. Both are 3-pentanol.

b)



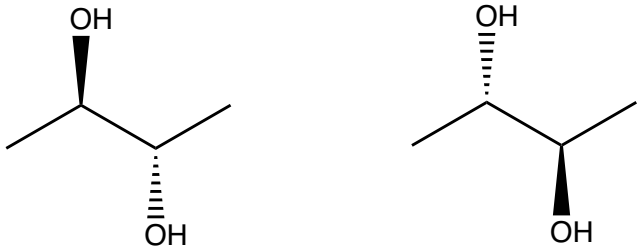
Diastereomers; There are 2 chiral centers, and only one differs between the two compounds.

c)



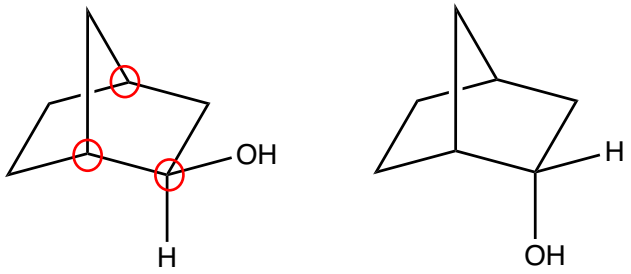
***Meso*-identical**; because of the internal plane of symmetry, these are not enantiomers, they are identical.

d)



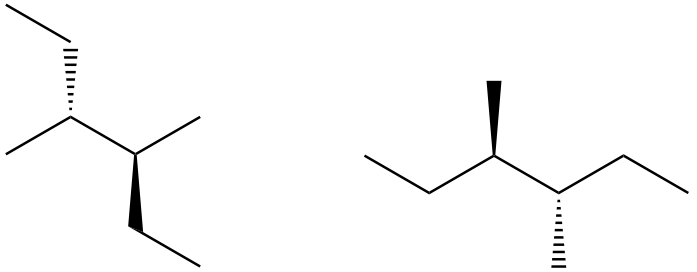
Meso-identical; There are 2 chiral centers, but there is an internal plane of symmetry when the central sigma bond is rotated 180°.

e)



Diastereomers; There are 3 chiral centers, only one is different between the two isomers.

f)

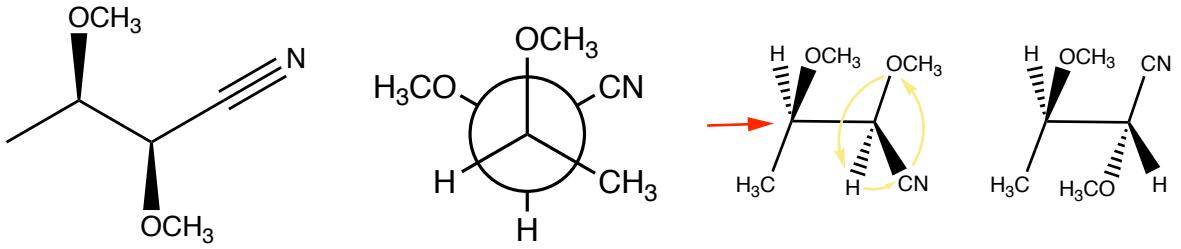


Meso-Identical; Both are 2,3-dimethylhexane. There are 2 chiral centers, but there is an internal plane of symmetry when the central sigma bond is rotated 180°.

6

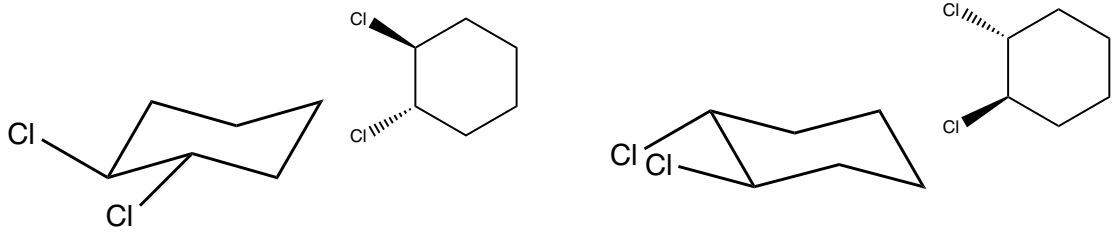
What is the relationship between the two compounds: identical, enantiomers, diastereomers?

a)



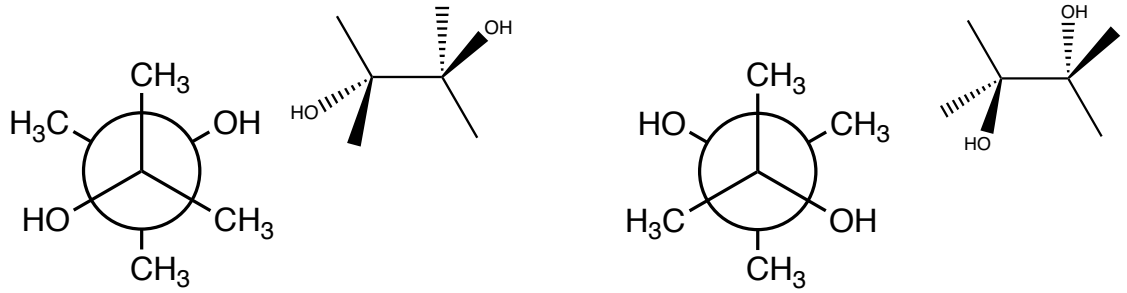
Diastereomers; Methyl ether has same configuration; nitrile ether has opposite configuration.

b)



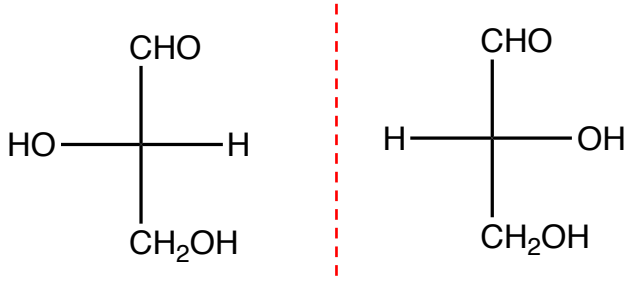
Enantiomers; left compound is (*S,S*) and right compound is (*R,R*).

c)



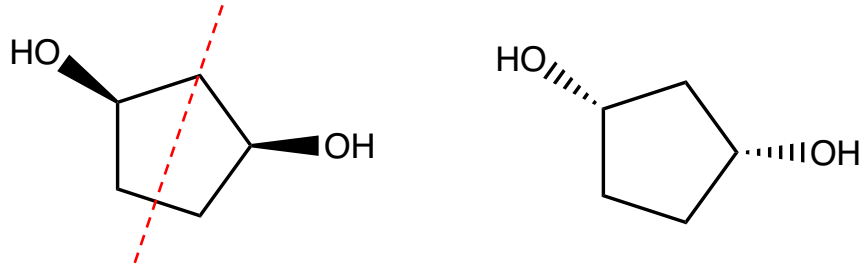
Identical; There is an internal plane of symmetry, but there are no chiral centers. Both are 2,3-dimethyl-butan-2,3-diol (do not need to know how to name diols).

d)



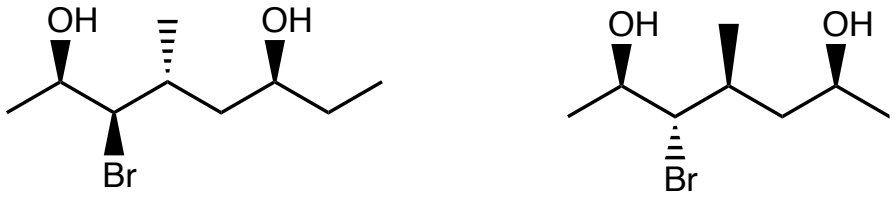
Enantiomers; molecule on right is mirror image of left. There is no plane of symmetry.

e)



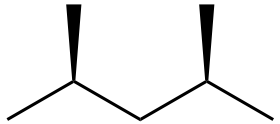
Meso-identical; there is an internal plane of symmetry, so these are not enantiomers, they are identical.

f)

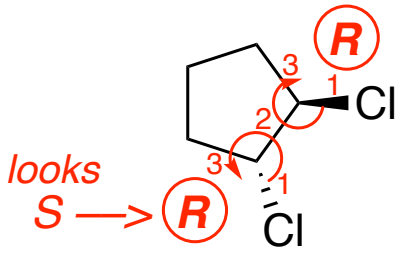


Diastereomers; left molecule is (*R,R,R,S*) and right is (*R,S,S,S*)

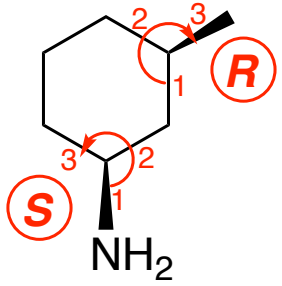
7 Is the compound chiral (C), achiral (A), or meso-achiral (M)? If appropriate, assign R/S stereochemistry.



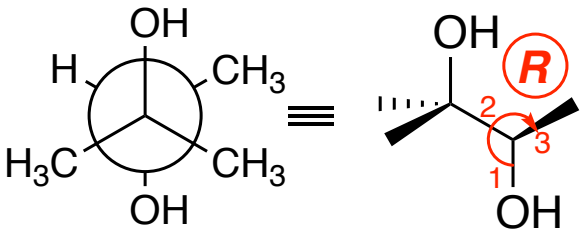
A



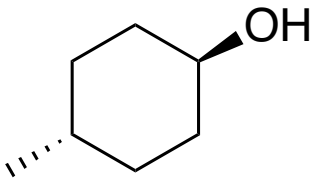
C (R, R)



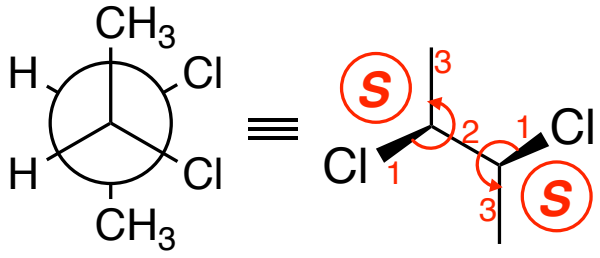
C (S, R)



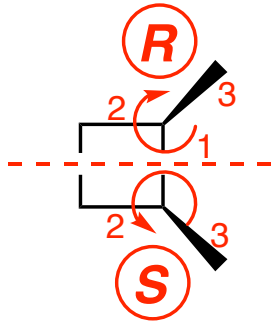
C (R)



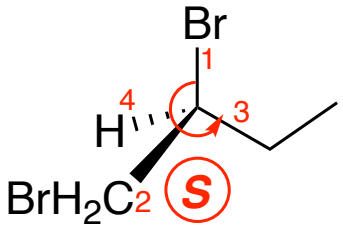
A, *trans*



C (S, S)

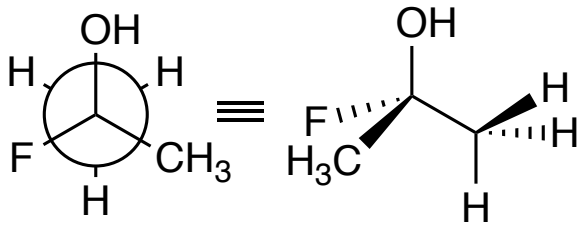


M (R, S)

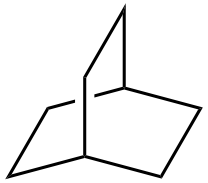


C (S)

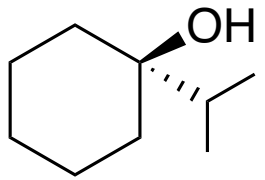
8 Is the compound chiral (C), achiral (A), or meso-achiral (M)? If appropriate, assign R/S stereochemistry.



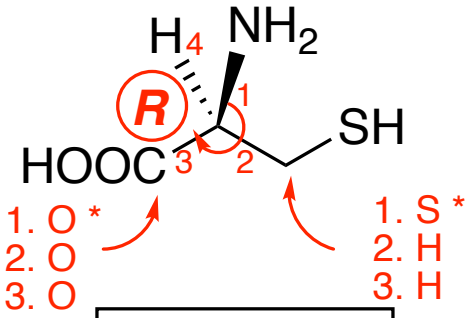
A



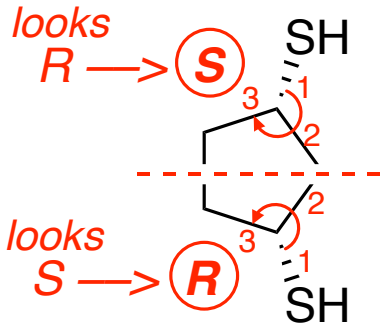
A



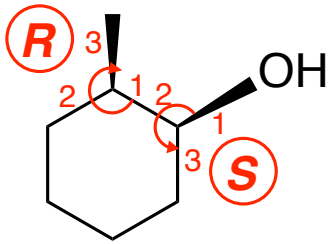
A



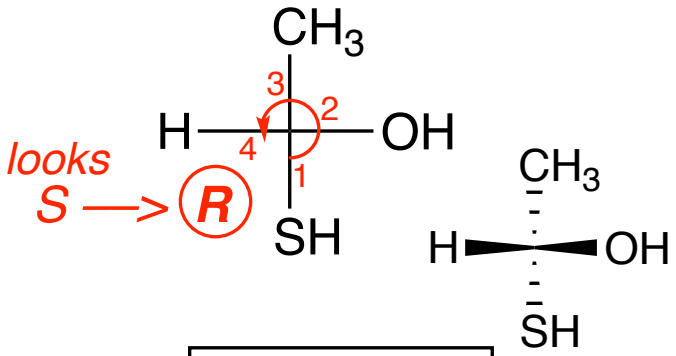
C (R)



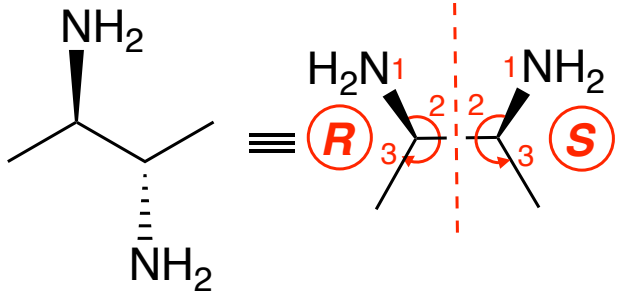
M (S, R)



C (R, S)



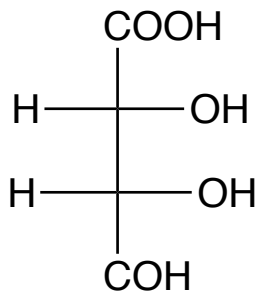
C (S)

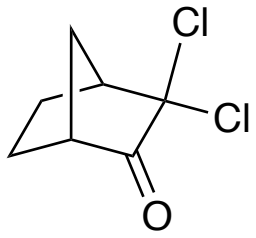


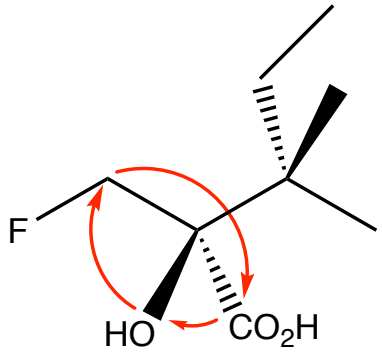
M (R, S)

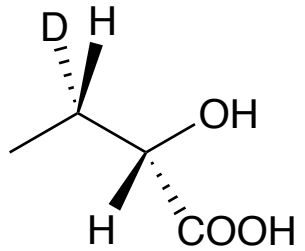
9

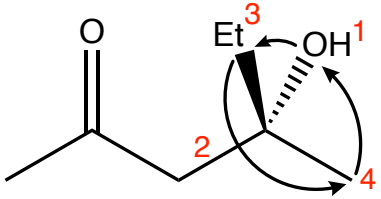
Is the compound chiral (C), achiral (A), or meso-achiral (M)? If appropriate, assign R/S stereochemistry.

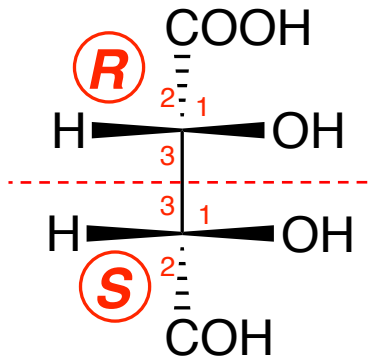




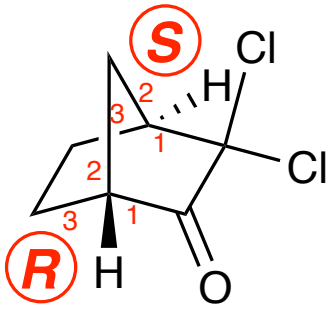




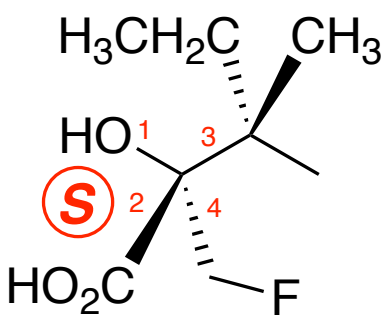




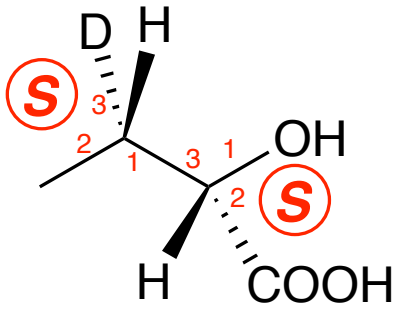
chiral



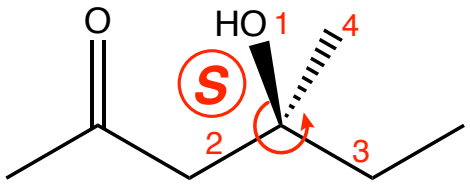
chiral



chiral



chiral



chiral

10

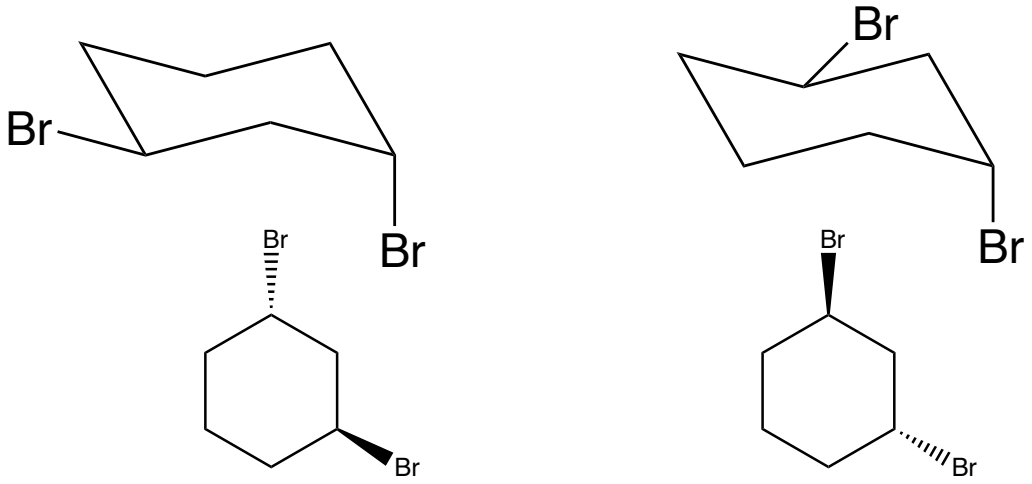
The two compounds are:

A. identical

B. enantiomers

C. diastereomers

D. conformational isomers



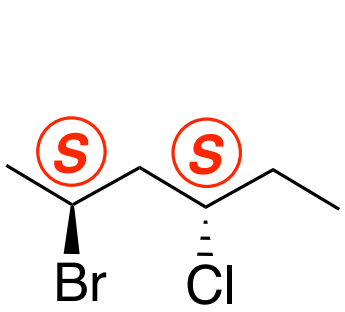
The two compounds are:

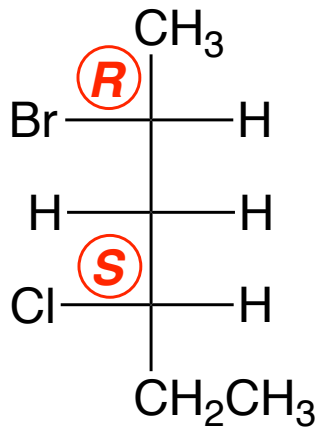
A. Identical

B. enantiomers

C. diastereomers

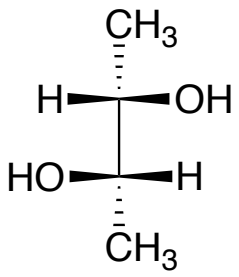
D. conformational isomers



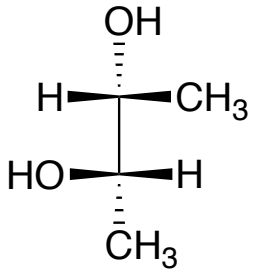


11

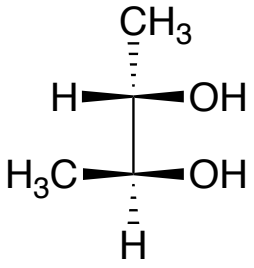
Which of the following compound(s) represent(s) *meso*-2,3-butanediol?



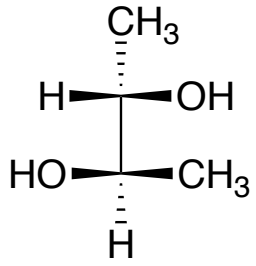
I.



II.



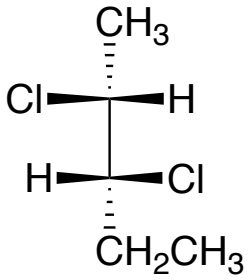
III.



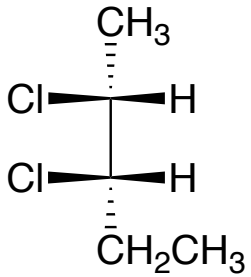
IV.

Struggling with Visualizing Fischer Projections? **Read 'Fischer Projection Practice'** in Support Materials folder on REC BB.

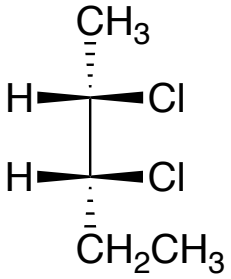
Which of the following compound(s) represent(s) (*S,S*)-2,3-dichloropentane?



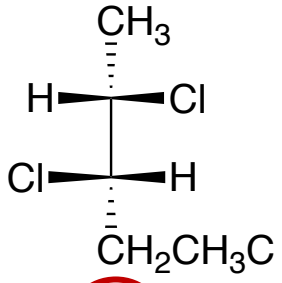
I.



II.



III.



IV.

12

A sample of 2-bromobutane has an enantiomeric excess (e.e.) of 75% favoring the *d*–enantiomer. What is the percentage of each enantiomer?

A. 87.5 % (–) enantiomer, 12.5% (+) enantiomer

B. 75% (+) enantiomer, 25% (–) enantiomer

C. 75% (–) enantiomer, 25% (+) enantiomer

D. 87.5% (+) enantiomer, 12.5% (–) enantiomer

Unrelated to R/S, there are (d) and (l) enantiomers.
Both enantiomers rotate light by the same magnitude.
- (d)-enantiomers rotate light in the (+) direction.
- (l)-enantiomers rotate light in the (–) direction.

75% *ee* of d-enantiomer = 75% (+) enantiomer
100% mixture – 75% (+) excess = 25% remaining –> 25% is racemic!

25% racemic is 50:50 of each enantiomer: 12.5% (+) and 12.5% (–).

Total (+) = 75% excess + 12.5% racemic **= 87.5%**
Total (–) = 12.5% racemic = **12.5%**

A mixture of enantiomers of tartaric acid that has an observed rotation of +6°. Optically pure *l*-tartaric acid has a specific rotation of –12°. What is the percent composition of each the *l* and *d* enantiomers?

A. 50% (+) enantiomer, 50% (–) enantiomer

B. 75% (+) enantiomer, 25% (–) enantiomer

C. 25% (+) enantiomer, 75% (–) enantiomer

D. 60% (+) enantiomer, 40% (–) enantiomer

E. 40% (+) enantiomer, 60% (+) enantiomer

Which enantiomer is in excess?
The observed rotation of the mixture is **+** 6°, therefore optic activity is due to excess of the (+) enantiomer.

$$\%ee = \frac{\alpha}{|\alpha|} \times 100\% = \frac{6}{12} \times 100\% = 0.5 \times 100\% = 50\%\ ee$$

If 50% is excess, then the remaining 50% must be racemic.
Total (+): 50% excess + 25% racemic = **75%**
Total (–): 25% racemic = **25%**

13

The specific rotation of (S)-butanol is +13.5. If 1.00 g of **its enantiomer** is dissolved in 10.0 mL of ethanol and placed in a sample cell with a length of 1.0 dm, what observed rotation would you expect?

From Klein, p. 196 $$\text{Specific rotation} = [\alpha] = \frac{\alpha}{c \times l}$$

This specific rotation [α] is determined under standard conditions:

- Path length = 1.0 dm
- Concentration = 1 g/mL

Given in this problem:

- Specific rotation of $[\alpha]_S$ = +13.5
- Specific rotation of $[\alpha]_R$ = –13.5 <——— We want the observed rotation of the **enantiomer**
- Path length (ℓ) = 1.0 dm
- Concentration (c): [S-butanol] = 1.0 g / 10 mL = 0.1 g/mL

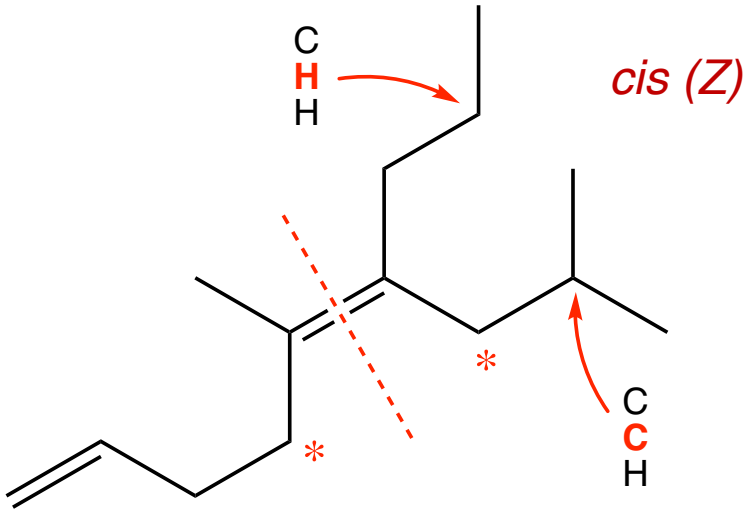
Calculate observed rotation for diluted sample.

Observed rotation (α) = $[\alpha]_S$ x (c x ℓ) = (–13.5)(0.1 g/mL)(1.0 dm) = – 1.35

For a sample diluted by 10x, we see only 10% of the typical polarization of light.

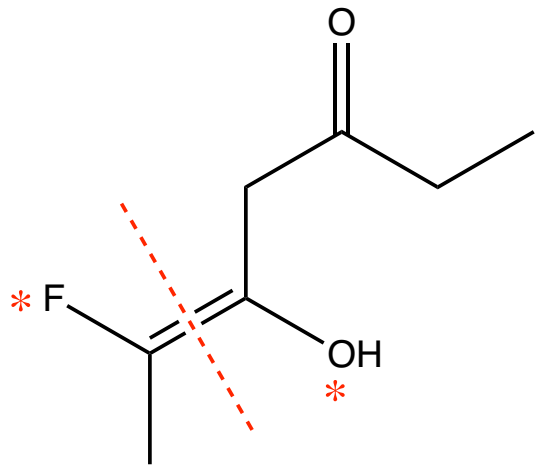
14 Identify the configurations of the following alkenes as E or Z.

a)



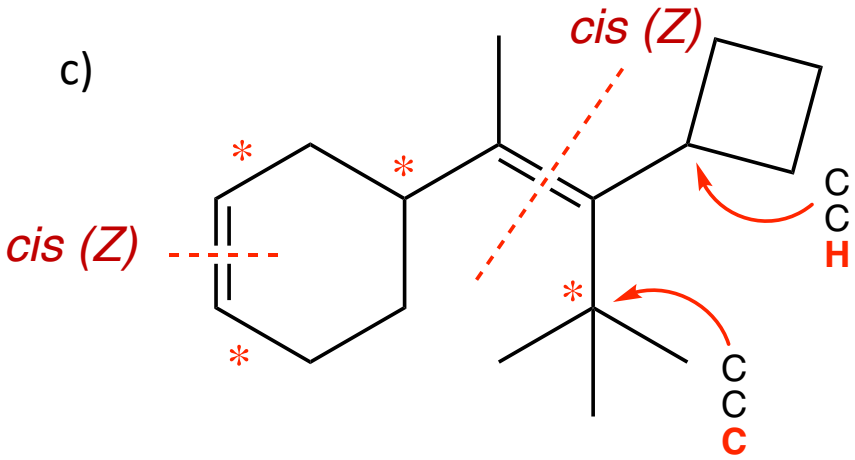
cis (Z)

b)

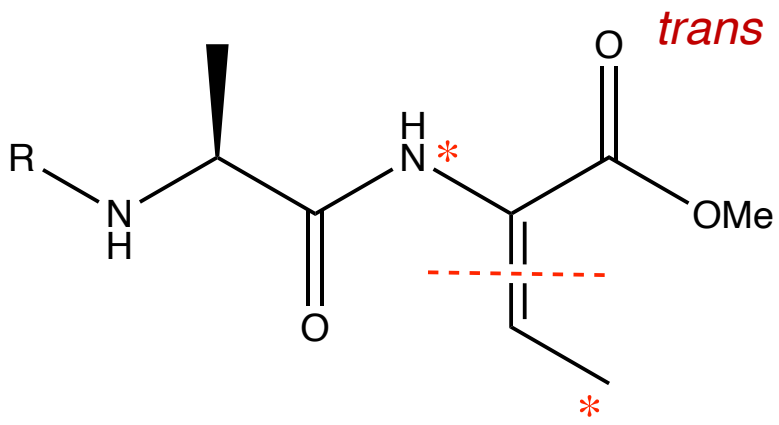


trans (E)

c)



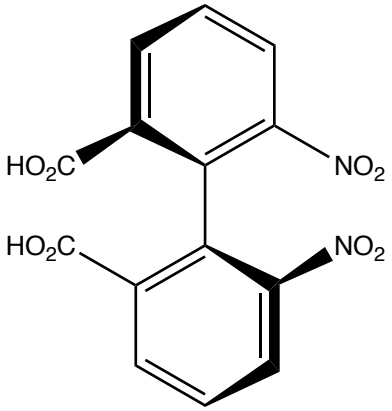
d)



trans (E)

Atropisomers & **Allenes**: Which of the following compounds is/are chiral?

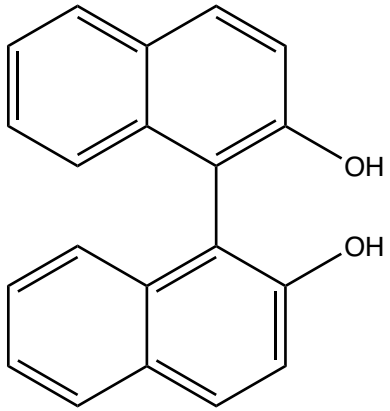
a)



chiral

Steric bulk prevents free rotation

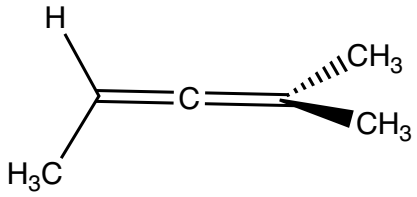
b)



chiral

Steric bulk prevents free rotation

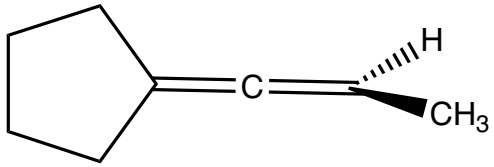
c)



achiral

Cannot assign priority to R side of allene because two groups are the same.

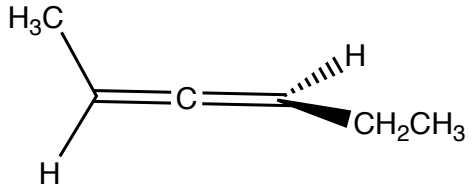
d)



achiral

Cannot assign priority to L side of allene because the ring is equal on both sides.

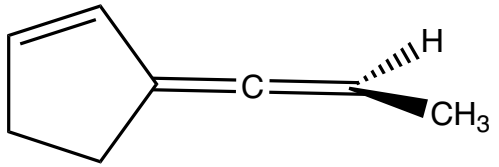
e)



chiral

Both sides can be assigned priority.

f)



chiral

Both sides can be assigned priority.