QUESTION BANK (Stereochemistry)

Question Bank for 3rd stage in the subject of stereochemistry is hereby given for the practice.

Q1) What is necessary and sufficient conditions for a molecule to become optical active?

A1) Its three-dimensional structure should not have a plane of symmetry

The two possible formulas should be non-superimposable mirror-images

Q2) What is position isomers, give one example?

A2) When two or more compounds differ in the position of substituent atom or functional group on the carbon skeleton, they are called position isomers, example 1-chloropropane and 2-chloropropane.

Q3) Give the difference between Stereospecific and Stereoselective Reactions.

A3) Stereoselectivity means that in a chemical reaction one stereoisomer or a small group of stereoisomers of several possible stereoisomers is preferentially or even exclusively produced.

A reaction is termed **stereospecific** if the stereoisomeric starting materials are converted into stereoisomeric products. If the configuration of the starting materials is known, then the product of a stereospecific reaction can be predicted.

Q4) Identify the chiral molecule in the following pair

A B

A4) Compound A is Chiral Molecule

Q5) Give reasons for the following:

(±)2-Butanol is optically inactive.

A5) See Racemic mixture in the lectures.

Q6) Explain briefly (in one or two short sentences) the meaning of the following
basic stereochemical terms.
a) chirality
b) constitution
c) configuration
d) conformation
e) stereoisomers

A6) a) Chirality is the property of an object (e.g., a molecule) of being nonsuperimposable on a mirror image like object.

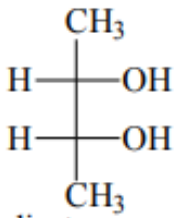
b) The **constitution** of a compound is the number and types of atoms contained in the compound along with information about how the atoms are connected to each other, and their bond order. It does not convey any information regarding their spatial arrangement.

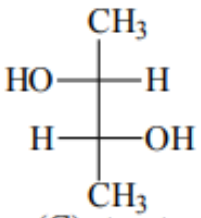
c) The **configuration** of a molecule is the spatial arrangement of atoms or groups of atoms in the molecule and is independent of rotation about any single bond.

d) The **conformation** of a molecule is the precise spatial arrangement of the atoms or groups of atoms in a molecule as a result of rotation about single bonds. There are an infinite number of possible conformations. However, only those conformational isomers possessing energy minima are referred to as **conformers**.

e) **Stereoisomers** are isomers with the same constitution but with different spatial arrangements of their atoms or groups. Stereoisomers may be subdivided into configurational isomers and conformational isomers. In both types the isomers are either enantiomers or diastereomers.

Q7) The relationship between the following two structures is:

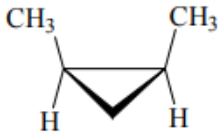




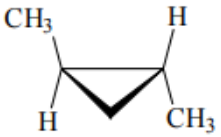
(A) enantiomers (B) diastereomers (C) structural isomers
(D) identical (E) none of the above

A7) **The answer is (B) (by definition)**

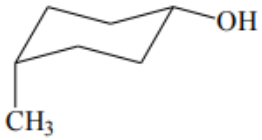
Q8) Which of the following molecules is chiral?



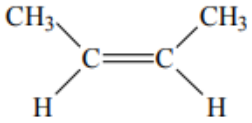
(A)



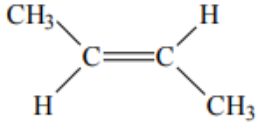
(B)



(C)



(D)



(E)

What is the relationship between (A) and (B) structures?

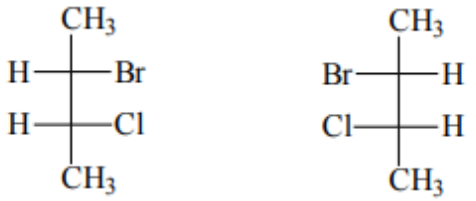
A8) Go by definition or look for plane of symmetry/point of inversion.

The answer is B.

The relationship between A and B, they are diastereomers

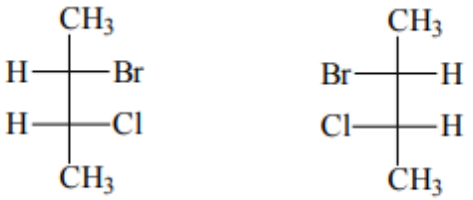
Q9) (A) Draw Fisher projections for

a- (2R, 3S)-2-bromo-3-chlorobutane and
(2S, 3R)-2-bromo3-chlorobutane,
with the carbon chain on the vertical line. Label each structure as (2R, 3S) or (2S, 3R).



(B) Assume that you have a mixture of equal amount of each of the above compounds. Can they be separated into two containers based on physical properties such as b.p., m.p., etc.? If yes, which technique would you use? If no, briefly explain why not.

A9) a-

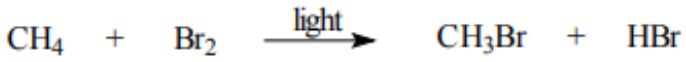


2S, 3R

2R, 3S

b- The two compounds as drawn are enantiomers which have identical b.p. and other physical properties (different only towards plane polarized light). **Therefore, they can't be separated based on physical properties alone.**

Q10) The following equation shows the bromination of methane.



Propose a mechanism to account for the product formation.

A10) See Chlorination of methane discussed in the lecture of the stereochemistry of Chemical reactions.

Q11) Name the instrument used for measuring the angle by which the plane polarized light is rotated.

A11) Polarimeter

Q12) What is plane polarized light?

A 12) See it in the lectures

Q13) Define the following terms: (i) Enantiomers (ii) Racemic mixture

A13) see it in the lectures

Q14) What is Chiral Synthesis?

The synthesis of a compound by a method that favors the formation of a specific enantiomer or diastereomer

Q15) Briefly describe the types of Stereoisomers

A15)

- **Enantiomers:** An enantiomer, also known as an optical isomer, antipode, or optical antipode, is one of two stereoisomers that are mirror images of each other but are non-superposable (not identical), similar to how one's left and right hands are mirror images of each other but are not identical simply by reorientation.
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- **Diastereomers:** Diastereomers (also known as diastereoisomers) are a form of stereoisomer. Diastereomers are characterized as non-image non-identical stereoisomers. As a result, they happen when two or more stereoisomers of the same compound have distinct configurations at one or more (but not all) of the equivalent (related) stereocenters and aren't mirror reflections of each other.

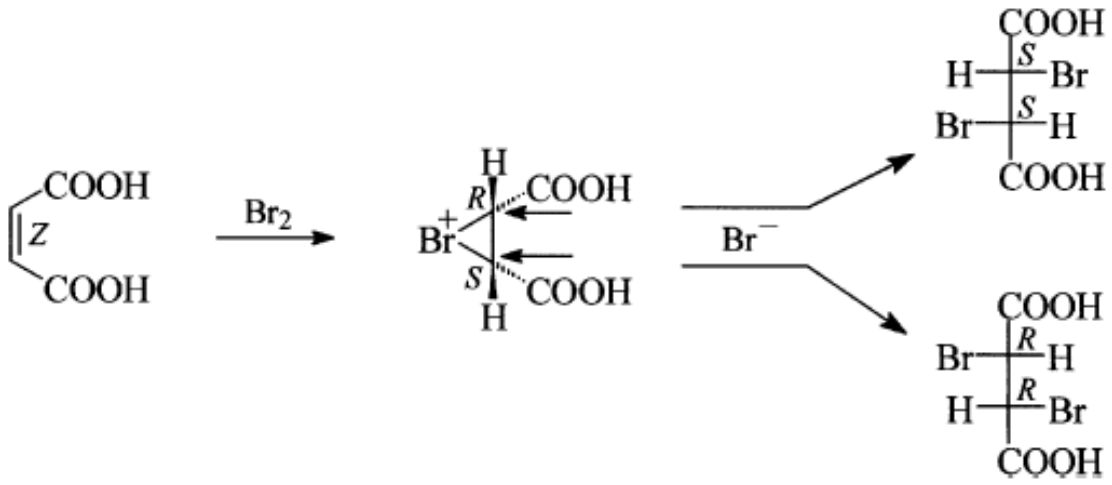
- Cis denotes that the functional groups (substituents) are on the same side of a plane, while trans expresses that they are on opposing (transverse) sides. Cis–trans isomers are stereoisomers, that are pairs of molecules that have the same formula but distinct functional groups in three-dimensional space.
- **Conformational isomerism:** Conformational isomerism is a type of stereoisomerism in which isomers can be changed by rotating them around formally single bonds. While any two atomic configurations in a molecule that differ by rotation about single bonds are called distinct conformations, conformations that correspond to local minima on the potential energy surface are called conformational isomers or conformers.

Q16) What is meant by the term absolute configuration and how is it specified?

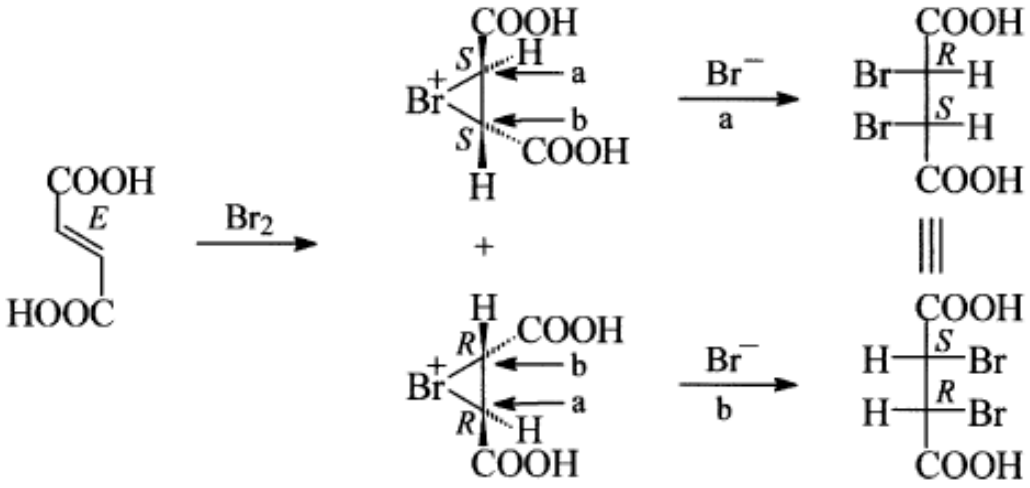
A16) See it in the lectures

Q17) What products are formed when
a) maleic acid and
b) fumaric acid
is treated with bromine in the cold and in the absence of light? Justify your answer from a consideration of the reaction mechanism.

A17) Maleic acid reacts first with molecular bromine with loss of a bromide Ion and the formation of a cyclic bromonium ion. In a second step the nucleophilic bromide ion can attack the cyclic bromonium ion. This attack proceeds as in a normal SN2 reaction stereo specifically with inversion. Since there is equal probability of attack by the bromide ion at C2 and C3 of the *meso*-bromonium ion, the product is the racemate of (2*R*,3*R*)- and (2*S*,3*S*)-dibromo succinic acid. It should be noted that the above reaction only proceeds in this manner in the absence of light and in the cold.

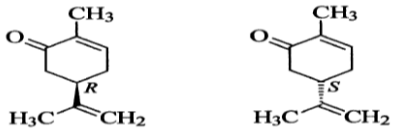


b) Under analogous conditions, fumaric acid yields two enantiomeric cyclic bromonium ions which have the *R*, *R* and *S*, *S* configuration, respectively. The subsequent ring opening of the three-membered ring by the nucleophilic attack of the bromide ion is independent on which of the bromonium ions is attacked. In either case the same product, (2*R*,3*S*)-dibromosuccinic acid (*meso*-2,3-dibromosuccinic acid), is produced, since nucleophilic attack always leads to inversion at one of the chirality centers. The two separates formulae shown below for the product are interconvertible by rotation through 180◦.



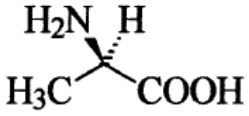
Q18) Which of the following properties or methods can be used to distinguish between (*R*)-carvone and (*S*)-carvone?

a) boiling point
b) UV spectroscopy
c) refractive index
d) melting point
e) smell
f) **optical rotation**
g) dipole moment
h) circular dichroism
i) NMR spectroscopy
j) IR spectroscopy



A18) (*R*)-Carvone and (*S*)-carvone are enantiomers and can be distinguished from each other by their optical rotations, by circular dichroism and by smell. Laevorotatory (*R*)-carvone has a spearmint smell (spearmint = *Mentha spicata*), whilst (*S*)-(+)-carvone has a caraway odor.

Q19) Determine the configuration of the isomer of the amino acid alanine shown below.



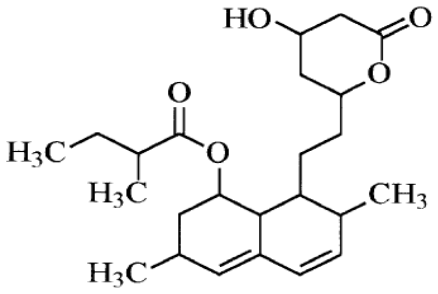
A19) R- configuration

N, COOH, CH3,

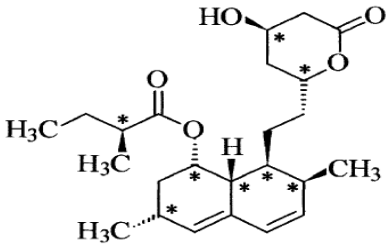
Q20) What is meant by the terms Meso compound?

A **meso compound** is an achiral diastereomer in a group of stereoisomers which also contains chiral isomers. It contains at least one symmetry element of the second kind (often a plane of symmetry) which transforms enantiomorphic parts of the molecule into each other.

Q21) Mark all the chirality centers in the formula of the lipid-lowering drug lovastatin shown below with an asterisk (*). How many chirality centers are present?



A21) Lovastatin has eight chirality centers.



Q22) Explain clearly and succinctly the following stereochemical terms.
a) inversion
b) prochiral

A22) a- The term **inversion** – depending on the context – has several meanings. It is most frequently used to describe the steric course of a substitution reaction when the arrangement of atoms or groups at a chirality center is reversed relative to the substituted group.

b-An achiral molecule is termed **prochiral** if it can be converted in a single transformation (chemical reaction) to a chiral molecule.

Q23) How many prochirality centers has butanone? Where are they in the molecule?

A23) There are two prochirality centers in butanone at carbon atoms 2 and 3.

Q24) Explain in a few short sentences what is meant by the term relative configuration.
Which stereo descriptors can be used to describe the relative configuration?

A24) Return to the lectures

Q25) What is meant by the term absolute configuration and how is it specified?

A25) The **absolute configuration** is the actual spatial arrangement of the atoms or groups at a stereogenic unit of a chiral compound or substructure and is unambiguously described by means of appropriate **stereo descriptors**. The stereo descriptors used to denote the absolute configuration depend upon both the structure and the type of compound. In general, for tetrahedrally or trigonal pyramidally coordinated chirality centers, the two possibilities are described by the stereo descriptors *R* and *S*.

Q26) Draw as Newman projections the different conformations of ethylene glycol (HO–CH2–CH2–OH) and label each clearly.

See the lecture

Q27) What is a Pseudo chirality center?
See Pseudo asymmetry in the lectures

Q28) Multiple Choice Questions & Answers (MCQs)

1- Compounds which have different arrangements of atoms in space while having same atoms bonded to each other are said to have
   a) position isomerism
   b) functional group isomerism
   c) chain isomerism
   d) stereoisomerism

A- **Answer: d**
Explanation: Stereoisomer his contrasts with structural isomers, which share the same molecular formula, but the bond connections or their order differs. By definition, molecules that are stereoisomers of each other represent the same structural isomer.

2- Which of the following can make difference in optical isomers?
a) heat
b) temperature
c) polarized light
d) pressure

Answer: c
Explanation: An optically active substance is one which can rotate the plane of polarization of plane polarized light. if you shine a beam of polarized monochromatic light (light of only a single frequency – in other words a single color) through a solution of an optically active substance, when the light emerges, its plane of polarization is found to have rotated.

3- Compounds with different atomic configurations in space but the same atoms bonded to each other are said to as having.

a) stereoisomerism

b) functional group isomerism

c) chain isomerism

d) position isomerism

Answer: a) stereoisomerism

Explanation: Stereoisomer varies from structural isomers, which have the same molecular formula but differ in their bond connections or order. Molecules that are stereoisomers of one other have the same structural isomer by definition.

4- Which of the following terms best describes the following pair of molecules?

a) Isomers

b) Geometrical isomers

c) Configurational isomers

d) Constitutional isomers

Answer: b) Geometrical isomers

Explanation: These molecules are isomers since they have the same chemical formula (C_7H_{14}). However, due to a double bond, the molecules' spatial orientations differ. And hence, the molecules can best be characterized as geometric isomers.

5- Which of the following alkanes has the ability to exhibit optical activity?

a) Neopentane

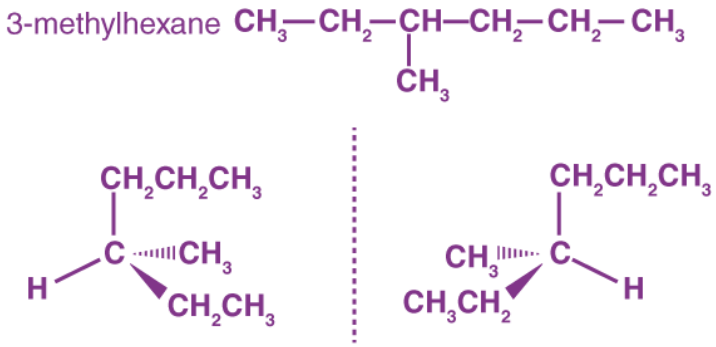
b) Isopentane

c) 3–Methyl pentane

d) 3–Methyl hexane

Answer: d) 3–Methyl hexane

Explanation: 3–Methyl hexane shows the optical activity as shown below:



6- **:** The given molecules are _____

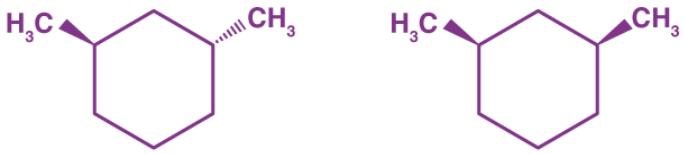
a. constitutional isomers

(b) conformers

(c) stereoisomers

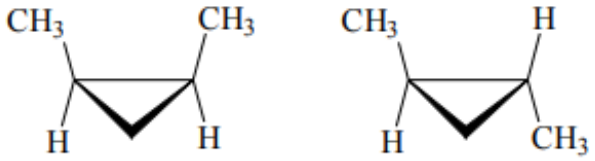
(d) identical

(e) None of these



Answer: **(c) stereoisomers**

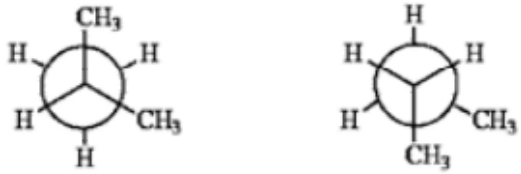
7- The relationship between (A) and (B) structures is:



(A) (B)

A) Identical
B) structural isomers
C) diastereomers
D) enantiomers
E) None of the above

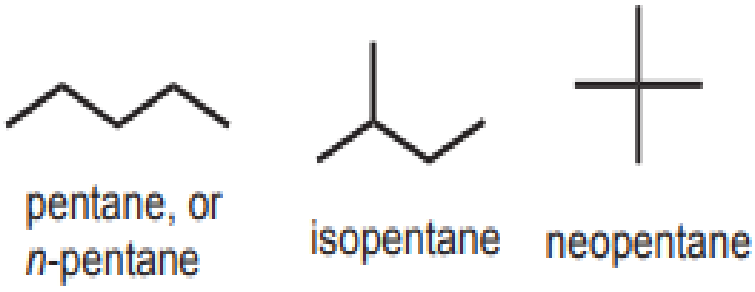
Q28) The structures below are:



a. Not isomers
b. Cis-trans isomers
c. Conformational isomer
d. Structural isomer
e. Both B and D

Q30) Give structures for the three isomers with molecular formula C_5H_{12} and provide the common name of each.

A30)



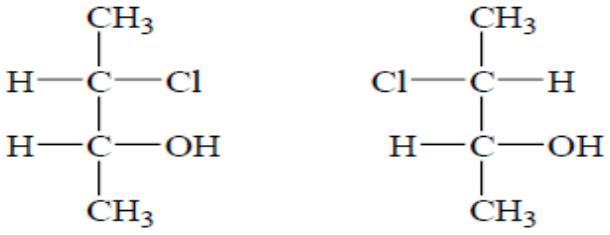
Q31) Why does the dry-cleaning solvent trichloroethene ($Cl_2C=CHCl$) not have geometric isomers?

For geometric isomer to exist there must **be two different groups attacked to each carbon of the double bond**.

Q32) What is meant by the terms Meso compound?

A33) A **Meso compound** is an achiral diastereomer in a group of stereoisomers which also contains chiral isomers. It contains at least one symmetry element of the second kind (often a plane of symmetry).

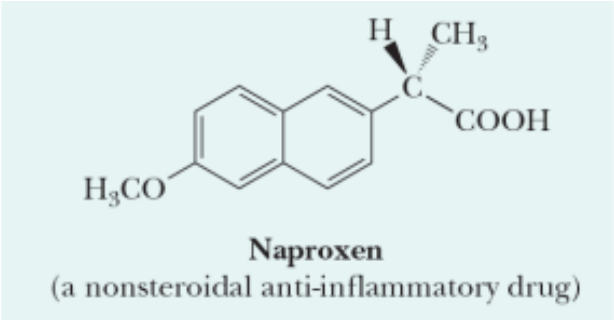
Q34) Name the Erythro and Threo nomenclature for 3-Chloro-2-butanol.



Erythro ***Threo***

3-Chloro-2-butanol

Q35) Naproxen is the active ingredient in Aleve and a score of other over-the-counter and prescription nonsteroidal anti-inflammatory drug preparations. Assign an R or S configuration to this enantiomer of naproxen.

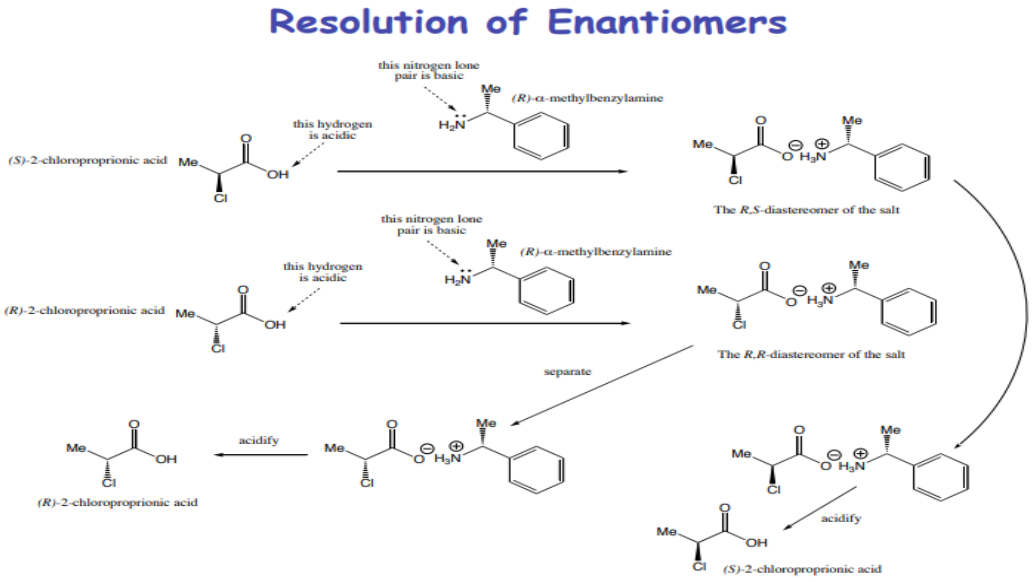


Naproxen
(a nonsteroidal anti-inflammatory drug)

A) S-configuration

B)

Q36) Separate the enantiomers of 2-chloropropionic acid from the racemic mixture Using (R)-α-methylbenzylamine as a chiral reagent.



Q37) Are the following compounds enantiomers or diastereomers?

a) (*E*)-1,2-dichloroethene and (*Z*)-1,2-dichloroethene
b) (+)-tartaric acid and *meso*-tartaric acid
c) (1*R*,2*S*)-cyclohexane-1,2-diamine and(1*R*,2*R*)-cyclohexane-1,2-diamine
d) (1*S*,2*S*)-cyclohexane-1,2-diamine and (1*R*,2*R*)-cyclohexane-1,2-diamine

A37)

a) (*E*)-1,2-Dichloroethene and (*Z*)-1,2-dichloroethene are diastereomers.
b) (+)-Tartaric acid and *meso*-tartaric acid are diastereomers.
c) (1*R*,2*S*)-Cyclohexane-1,2-diamine and (1*R*,2*R*)-cyclohexane-1,2-diamine are diastereomers.
d) (1*S*,2*S*)-Cyclohexane-1,2-diamine and (1*R*,2*R*)-cyclohexane-1,2-diamine are enantiomers.