Stereochemistry

1. What is stereochemistry?

A) The study of reaction rates
B) The study of the 3D arrangement of atoms in molecules
C) The study of ionic bonding
D) The study of molecular weights

2. Enantiomers are non-superimposable mirror images of each other. They differ in:

A) Molecular formula
B) Connectivity of atoms
C) Configuration at chiral centers
D) Boiling point in achiral solvents

3. A chiral center (stereocenter) is a carbon atom bonded to:

A) Four identical groups
B) Four different groups
C) Three different groups
D) Two double bonds

4. Which of the following is a chiral molecule?

A) CH4
B) CHFClBr
C) CH2Cl2
D) CCl4

5. The R/S configuration system is based on:

A) Optical rotation direction
B) CIP (Cahn-Ingold-Prelog) priority rules
C) Melting point differences
D) Molecular weight

6. In CIP rules, priority is assigned based on:

A) Alphabetical order of element symbols
B) Atomic number of directly attached atoms
C) Molecular weight of substituents
D) Electronegativity only

7. If priorities 1→2→3 go clockwise (with priority 4 pointing away), the configuration is:

A) S
B) R
C) E
D) Z

8. Diastereomers are stereoisomers that are:

A) Non-superimposable mirror images
B) Superimposable mirror images
C) Not mirror images of each other
D) Constitutional isomers

9. A meso compound is:

A) Optically active with two stereocenters
B) Achiral despite having stereocenters due to internal symmetry
C) Always a racemic mixture
D) A compound with no stereocenters

10. A racemic mixture contains:

A) Only R enantiomer
B) Only S enantiomer
C) Equal amounts of R and S enantiomers
D) Diastereomers in equal amounts

11. Which property differs between enantiomers?

A) Melting point
B) Boiling point
C) Optical rotation direction
D) Solubility in achiral solvents

12. The specific rotation of the R enantiomer is +20°. What is the specific rotation of the S enantiomer?

A) +20°
B) 0°
C) -20°
D) +40°

13. How many stereocenters does a molecule need to potentially have enantiomers?

A) At least 2
B) At least 1
C) At least 3
D) Zero

14. The maximum number of stereoisomers for a molecule with n stereocenters is:

A) n
B) 2n
C) n^2
D) 2^n

15. Cis-trans isomerism in alkenes is also called:

A) Conformational isomerism
B) Geometric isomerism
C) Optical isomerism

D) Structural isomerism

16. In the E/Z naming system, E (entgegen) means the higher priority groups are:

A) On the same side
B) On opposite sides
C) Pointing away from each other
D) In axial positions

17. Which of the following can show cis-trans isomerism?

A) CH2=CH2
B) CH3-CH=CH-CH3
C) CH2=CCl2
D) (CH3)2C=CH2

18. Conformational isomers (conformers) differ in:

A) Connectivity of atoms
B) Configuration at stereocenters
C) Rotation around single bonds
D) Number of atoms

19. In cyclohexane, the most stable conformation is:

A) Boat form
B) Half-chair form
C) Chair form
D) Twist-boat form

20. In a chair cyclohexane, axial bonds are:

A) In the plane of the ring
B) Perpendicular to the mean plane of the ring
C) All pointing upward
D) At 109.5° to each other

21. The term 'optical activity' refers to:

A) Absorption of UV light
B) Rotation of plane-polarized light
C) Emission of visible light
D) Refraction of light

22. A compound with [α] = 0 is:

A) Always achiral
B) Optically inactive (could be achiral or racemic)
C) Always a meso compound
D) Always a racemic mixture

23. In a Fischer projection, horizontal bonds point:

A) Away from the viewer
B) Toward the viewer

C) In the plane of the paper
D) Upward

24. In a Newman projection, the front carbon's bonds are drawn as:

A) Dashed lines
B) Lines from the center of the circle
C) Lines to the circle
D) Wedge bonds

25. The anti conformation in a Newman projection has a dihedral angle of:

A) 0°
B) 60°
C) 120°
D) 180°

26. Gauche conformation refers to a dihedral angle of approximately:

A) 0°
B) 60°
C) 120°
D) 180°

27. Which conformation of ethane is most stable?

A) Eclipsed
B) Gauche
C) Staggered
D) Syn

28. Torsional strain arises from:

A) Non-bonded atom interactions
B) Bond angle distortions
C) Eclipsing of bonds in rotation
D) Ionic repulsions

29. Van der Waals strain (steric strain) is caused by:

A) Eclipsing interactions
B) Bond angle compression
C) Non-bonded atoms being too close
D) Lone pair repulsion

30. Ring strain in cyclopropane is primarily due to:

A) Torsional strain only
B) Angle strain (bond angles compressed to ~60°)
C) Steric strain only
D) Hydrogen bonding

31. In a trans-decalin, the ring junction hydrogens are:

A) Both axial

B) Both equatorial
C) One axial and one equatorial
D) Both absent

32. What is an epimer?

A) Two enantiomers
B) Diastereomers differing at only one stereocenter
C) A meso compound
D) A racemic mixture

33. Anomers in carbohydrate chemistry are:

A) Enantiomers of sugars
B) Epimers at the anomeric carbon (C-1)
C) Diastereomers differing at C-2
D) Constitutional isomers of sugars

34. D and L sugars are defined based on the configuration at:

A) The anomeric carbon
B) The highest-numbered stereocenter
C) The carbon bearing the carbonyl group
D) Any stereocenter

35. In D-glucose, the configuration at C-5 is the same as:

A) L-glyceraldehyde
B) D-glyceraldehyde
C) A meso compound
D) The S configuration always

36. The R/S designation of a chiral center can change without breaking any bonds when:

A) Temperature changes
B) A substituent's priority ranking changes relative to others
C) The molecule is dissolved
D) The molecule rotates in space

37. Axial substituents in cyclohexane experience 1,3-diaxial interactions with:

A) Adjacent equatorial substituents
B) Axial substituents on C-3 and C-5
C) Equatorial substituents on C-3
D) The ring carbons only

38. Which of the following has the highest ring strain?

A) Cyclohexane
B) Cyclopentane
C) Cyclobutane
D) Cyclopropane

39. A polarimeter is used to measure:

A) Molecular weight
B) Optical rotation of chiral compounds
C) Refractive index
D) Melting point

40. The enantiomeric excess (ee) of a sample that is 80% R and 20% S is:

A) 80%
B) 20%
C) 60%
D) 50%

41. In a SN2 reaction at a chiral center, the stereochemical outcome is:

A) Retention of configuration
B) Racemization
C) Inversion of configuration (Walden inversion)
D) Formation of meso compound

42. SN1 reactions at chiral centers generally give:

A) Complete inversion
B) Complete retention
C) Racemization or partial racemization
D) Only the R product

43. Which reaction proceeds with syn addition?

A) Halogenation of alkenes (Br2/CCl4)
B) Catalytic hydrogenation of alkenes
C) Ozonolysis
D) E2 elimination

44. Halogenation of alkenes (Br2 addition) proceeds with:

A) Syn addition
B) Anti addition via bromonium ion
C) No stereochemical preference
D) Retention at both carbons

45. E2 elimination requires the leaving group and beta hydrogen to be:

A) Syn periplanar
B) Gauche
C) Anti periplanar
D) Eclipsed

46. In the Diels-Alder reaction, the stereochemistry is:

A) Anti addition
B) Non-stereospecific
C) Syn addition (suprafacial)
D) Radical mechanism

47. The endo rule in Diels-Alder reactions refers to:

A) The exo product being kinetically preferred
B) Secondary orbital interactions favoring endo transition state
C) Anti addition preference
D) Formation of trans product only

48. Retention of configuration occurs in which type of reaction?

A) SN2
B) SN1 (partially)
C) Front-side attack (rare, e.g. SNi)
D) E2

49. What is the relationship between (2R,3R)-tartaric acid and (2S,3S)-tartaric acid?

A) Identical compounds
B) Diastereomers
C) Enantiomers
D) Meso compounds

50. What is the relationship between (2R,3S)-tartaric acid and (2S,3R)-tartaric acid?

A) Enantiomers
B) Identical (meso compound)
C) Diastereomers
D) Constitutional isomers

51. Chiral HPLC is used to:

A) Determine molecular weight
B) Separate enantiomers
C) Identify functional groups
D) Measure optical rotation directly

52. Resolution of a racemic mixture means:

A) Converting it to a meso compound
B) Separating it into pure enantiomers
C) Measuring its optical rotation
D) Destroying one enantiomer

53. A prochiral center is a carbon that becomes chiral when:

A) It loses a hydrogen
B) One of two identical substituents is replaced by a different group
C) The molecule is heated
D) The molecule is dissolved in water

54. Re and Si faces of a carbonyl group are used to describe:

A) E/Z isomerism
B) The two faces of a trigonal planar center
C) Axial/equatorial positions
D) Rotation about single bonds

55. Homotopic protons, when replaced, give:

A) Enantiomers
B) Diastereomers
C) Identical compounds
D) Constitutional isomers

56. Enantiotopic protons, when replaced, give:

A) Identical compounds
B) Enantiomers
C) Diastereomers
D) Meso compounds

57. Diastereotopic protons, when replaced, give:

A) Enantiomers
B) Identical compounds
C) Diastereomers
D) Racemic mixture

58. In a trans-4-methylcyclohexanol (most stable chair), the methyl group is:

A) Axial
B) Equatorial
C) Both axial and equatorial
D) In the plane of the ring

59. The term atropisomers refers to:

A) Conformational isomers of cyclohexane
B) Stereoisomers arising from restricted rotation about a single bond
C) Enantiomers of amino acids
D) Anomers of sugars

60. Allenes (R-CH=C=CH-R') can show chirality because:

A) They have a chiral carbon
B) The two ends are in perpendicular planes giving axial chirality
C) They have restricted rotation
D) They have a meso form

61. In amino acids, the naturally occurring L-amino acids have the configuration:

A) R at the alpha carbon always
B) S at the alpha carbon (except cysteine)
C) D configuration
D) Always achiral

62. Absolute configuration refers to:

A) The direction of optical rotation
B) The actual 3D spatial arrangement of atoms at a stereocenter
C) The relative stability of conformers
D) The melting point of the pure enantiomer

63. Relative configuration describes:

A) The actual 3D arrangement compared to a reference compound
B) The direction of optical rotation
C) The ring conformation
D) The E/Z designation

64. Which of the following is achiral?

A) Lactic acid
B) 2-bromobutane
C) Propane
D) Alanine

65. The number of possible stereoisomers for glucose (4 stereocenters) is:

A) 4
B) 8
C) 16
D) 32

66. Which reagent is used to determine absolute configuration experimentally?

A) Polarimetry alone
B) X-ray crystallography (anomalous dispersion)
C) NMR only
D) Melting point measurement

67. A plane of symmetry in a molecule indicates the molecule is:

A) Chiral
B) Achiral
C) Always a meso compound
D) Optically active

68. The chair flip in cyclohexane converts:

A) Axial to equatorial and equatorial to axial substituents
B) Cis to trans isomers
C) R to S configuration
D) Gauche to anti conformers

69. In (1R,2S)-1-bromo-2-chlorocyclohexane, the two substituents are:

A) Both axial in the most stable form
B) Both equatorial
C) One cis to each other
D) Trans to each other

70. The stereospecific reaction produces:

A) A racemic mixture always
B) A specific stereoisomer depending on the stereochemistry of the starting material
C) A meso compound
D) No stereochemical control

71. Stereoselective reactions:

A) Give equal amounts of all stereoisomers
B) Preferentially form one stereoisomer over others
C) Only occur with chiral reagents
D) Always give 100% ee

72. The Cahn-Ingold-Prelog rules assign priority based on:

A) Alphabetical order
B) Decreasing atomic number
C) Increasing atomic mass
D) Electronegativity

73. In a Fischer projection of D-glyceraldehyde, the OH group at C-2 points:

A) To the left
B) Upward
C) To the right
D) Downward

74. The term 'threo' in older nomenclature refers to diastereomers resembling:

A) Erythrose (same side substituents in Fischer)
B) Threose (opposite side substituents in Fischer)
C) Glucose configuration
D) Meso compounds

75. When two stereocenters have opposite configurations (R,S), the relationship in a 2-carbon chain resembles:

A) Erythro (like)
B) Threo (unlike)
C) Always meso
D) Always racemic

76. Asymmetric synthesis aims to produce:

A) Racemic mixtures
B) Meso compounds only
C) One enantiomer preferentially
D) Achiral products only

77. Chiral auxiliaries are used to:

A) Racemize a compound
B) Induce asymmetry in a reaction then be removed
C) Measure optical rotation
D) Separate enantiomers by distillation

78. The Sharpless epoxidation is used to make:

A) Racemic epoxides
B) Enantiomerically enriched epoxides from allylic alcohols
C) Diols from alkenes

D) Ketones from epoxides

79. Enzymatic reactions are typically:

A) Non-stereospecific
B) Highly stereospecific and enantioselective
C) Racemizing
D) Non-selective

80. The optical purity of a sample is calculated as:

A) [α]obs / [α]max × 100%
B) [α]obs × concentration
C) [α]max - [α]obs
D) Moles of R / total moles

81. Which of the following is a diastereomeric salt used in resolution?

A) Racemic acid + achiral base
B) Racemic acid + optically pure chiral base
C) Meso compound + any base
D) Racemic base + achiral acid

82. In carbohydrates, mutarotation refers to:

A) Rotation of plane-polarized light
B) Change in optical rotation due to interconversion of anomers
C) Epimerization at C-2
D) Ring opening to straight chain

83. The alpha anomer of D-glucose has the OH at C-1:

A) Equatorial (trans to C-6 substituent)
B) Axial (trans ring junction)
C) Axial (same side as C-6 substituent for D-series)
D) Always equatorial

84. Helical chirality is observed in:

A) Simple alkanes
B) Helicenes and helical polymers
C) Meso compounds
D) Racemic mixtures

85. The diastereomeric excess (de) is analogous to ee but applies to:

A) Enantiomers
B) Diastereomers
C) Conformers
D) Meso compounds

86. Which of the following reactions is stereospecific with syn addition?

A) Free radical bromination
B) Osmium tetroxide dihydroxylation

C) NBS bromination
D) E1 elimination

87. Anti dihydroxylation can be achieved using:

A) OsO_4
B) mCPBA followed by acid hydrolysis of epoxide
C) $KMnO_4$ (cold)
D) Br_2/H_2O

88. In the context of enzyme active sites, only one enantiomer is often active because:

A) The other enantiomer is toxic
B) The active site is chiral and only fits one enantiomer
C) The other enantiomer has different molecular weight
D) Enzymes cannot bind any chiral molecules

89. The term 'scalemic' describes a mixture that is:

A) Purely one enantiomer
B) Racemic
C) Non-racemic (unequal enantiomers)
D) Meso

90. Planar chirality arises from:

A) A chiral carbon
B) Restricted rotation
C) A plane containing a chiral arrangement of groups
D) Axial chirality only

91. The IUPAC descriptor for axial chirality in allenes and biaryls is:

A) R/S only
B) Ra/Sa or aR/aS
C) E/Z
D) D/L

92. The conversion of one enantiomer to its mirror image requires:

A) Breaking and reforming bonds
B) No chemical change, just physical rotation
C) A chiral catalyst
D) High temperature only

93. In a molecule with two stereocenters where both are R, the relationship to the (S,S) isomer is:

A) Identical
B) Diastereomeric
C) Enantiomeric
D) Meso

94. Which technique directly determines enantiomeric ratio (er)?

A) Simple polarimetry
B) Chiral HPLC or chiral GC
C) Melting point
D) IR spectroscopy

95. The kinetic resolution of a racemate involves:

A) Separating enantiomers by crystallization
B) Reacting enantiomers at different rates with a chiral reagent
C) Converting to diastereomeric salts
D) Distillation of enantiomers

96. Dynamic kinetic resolution (DKR) combines:

A) Asymmetric synthesis with distillation
B) Kinetic resolution with in situ racemization of the slow-reacting enantiomer
C) Chiral HPLC with NMR
D) Two asymmetric reactions in sequence

97. Topicity (homotopic, enantiotopic, diastereotopic) is a concept used to classify:

A) Faces and groups in a molecule
B) Types of isomers
C) Conformational isomers
D) Ring strain types

98. Which of the following correctly describes a meso compound?

A) Optically active with multiple stereocenters
B) Has stereocenters but is achiral due to an internal mirror plane
C) Is always a racemic mixture
D) Has no stereocenters

99. In the context of thalidomide, the two enantiomers differ in:

A) Molecular weight
B) Biological activity (one is teratogenic, one is therapeutic)
C) Color
D) Solubility only

100. The stereodescriptor 'syn' in aldol reactions refers to:

A) The anti product
B) The OH and methyl on the same face (same side in Fischer projection)
C) A racemic mixture
D) E-geometry of the enolate