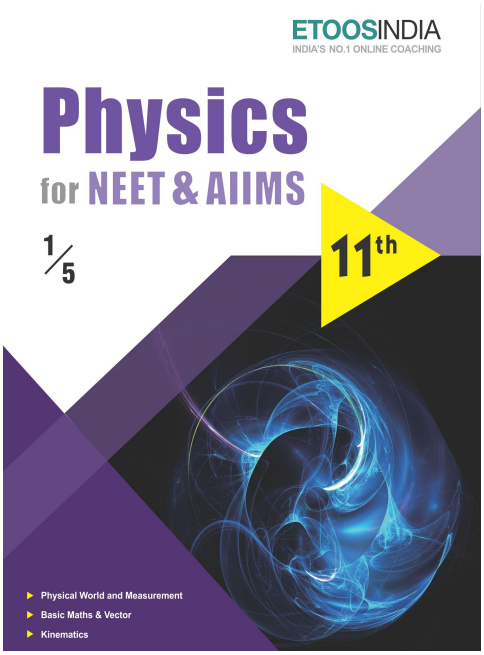
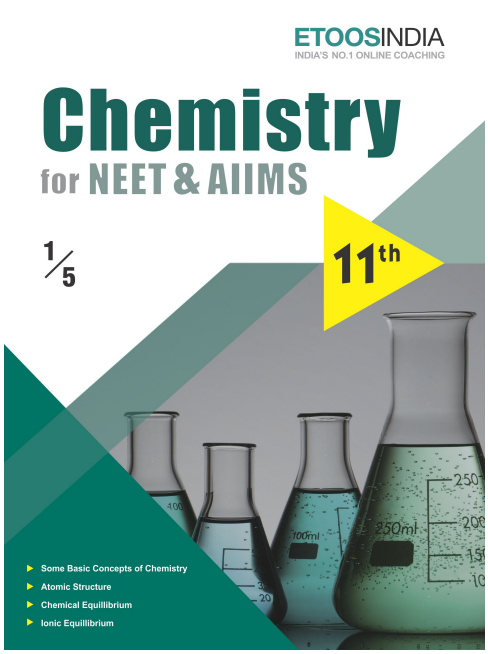
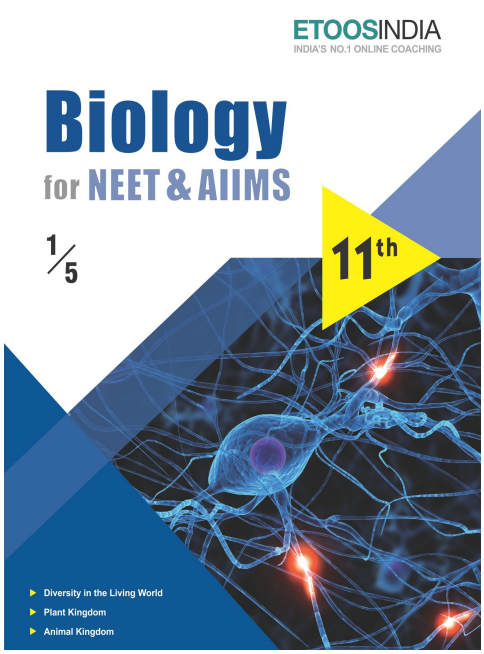
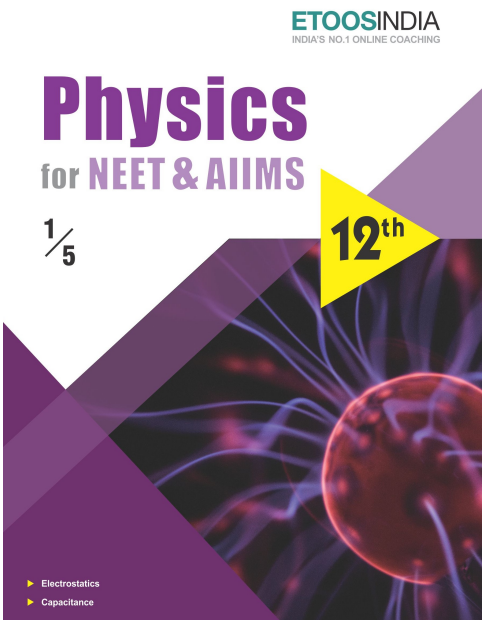
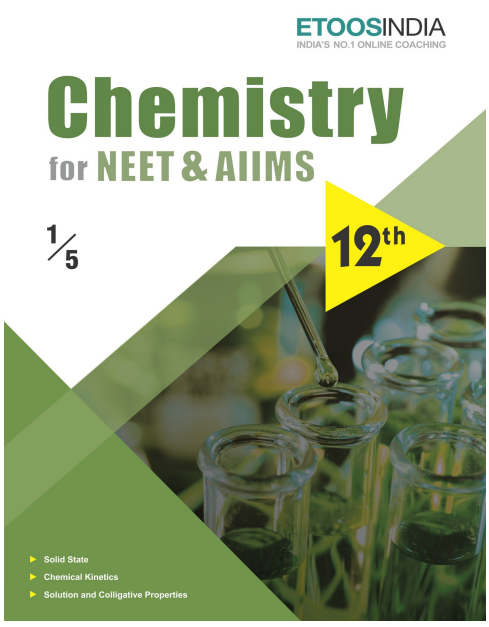
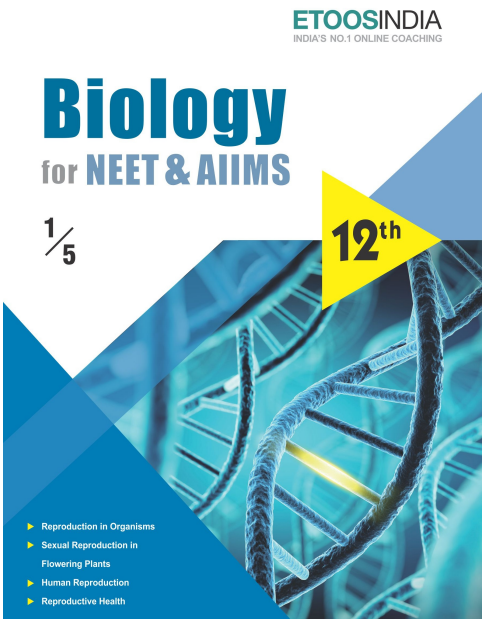












CHAPTER 13

ISOMERISM

The same number of atoms combined in the same way produces the same crystalline form, and the same crystalline form is independent of the chemical nature of the atoms, and is determined only by their number and relative position.

"EILHARD MITSCHERLICH"

INTRODUCTION

An isomer (isos = "equal", méros = "part") is a molecule with the same molecular formula as another molecule, but with a different chemical structure. That is, isomers contain the same number of atoms of each element, but have different arrangements of their atoms. Isomers do not necessarily share similar properties, unless they also have the same functional groups. There are two main forms of isomerism : ***structural isomerism*** (or constitutional isomerism) and ***stereoisomerism*** (or spatial isomerism).

The name was given by ***Berzilius***.

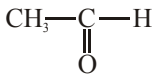
Isomerism is actually permutation and combination of arrangement of atoms in different style either structurally or 3 –dimensionally to form molecules by the nature.

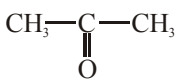
ETOOS KEY POINTS

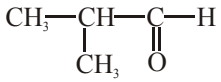
(i) Number of electron and lone pairs in both tautomers always remain the same.
(ii) It is a chemical phenomenon which takes place only in liquids and gaseous phase only. It never takes place in solid state.
(iii) The process can be catalyzed by the acid as well a bases.
(iv) Tautomers are also F.I. and exist in dynamic equilibrium $\rightleftharpoons$ is used to show tautomerism.

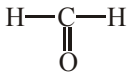
Condition for Tautomerism

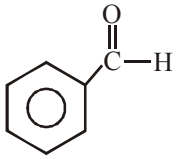
(a) For carbonyl compounds : Carbonyl compounds having **atleast one α-H** show tautomerism

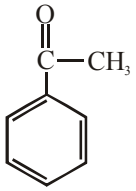
(i)  3 α H, show tautomerism.

(ii)  6 α H, show tautomerism.

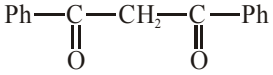
(iii)  1 α H, show tautomerism.

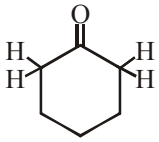
(iv)  No α H, No tautomerism.

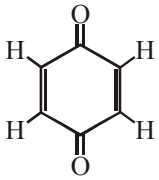
(v)  No α H, No tautomerism.

(vi)  3 α H, show tautomerism (Aceto phenone)

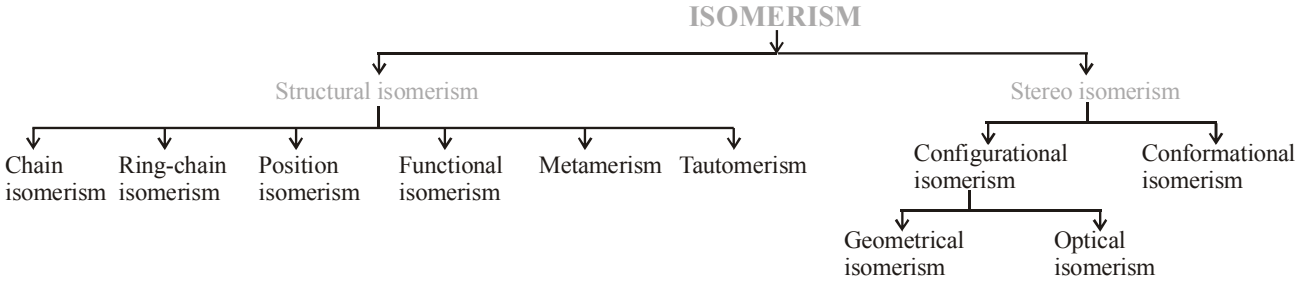
(vii)  No α H, No tautomerism (Benzophenone)

(viii)  2 α H, show tautomerism

(ix)  4 α H, show tautomerism

(x)  α H, attached sp^2 carbon does not take part in tautomerism

Etoos Tips & Formulas



STRUCTURAL ISOMERISM

1	**Chain Isomers**	They have different size of main chain or side chain	They have same nature of locant
2	**Positional Isomers**	They have different position of locant	They should have same size of main chain and side chain and same nature of locant
3	**Functional Isomers**	Different nature of locant	Chain and positional isomerism is not considered
4	**Metamerism**	Different nature of alkyl group along a polyvalent functional group	They should have same nature of functional group chain & positional isomer is ignored
5	**Tautomerism**	Different position of hydrogen atoms	The two functional isomers remains in dynamics equilibrium with each other

Meso compounds are those compounds whose molecules are superimposable on their images in spite of the presence of asymmetric carbon atom.

An equimolar mixture of the enantiomers (d & ℓ) is called **racemic mixture**. The process of converting of d-and ℓ- form of an optically active compound into racemic form is called **racemisation**.

The process by which dℓ mixture is separated into d and ℓ form with the help of chiral reagent or chiral catalyst is known as **resolution**.

Compound containing chiral carbon my or may not be optically active but show optical isomerism.

For optical isomer chiral carbon is not the necessary condition.

Case - 1 When the molecule is unsymmetrical. (It cannot be divided into two halves)

Number of d and ℓ isomers = 2^n
Number of meso form = 0
Total number of optical isomers = 2^n

Where n is the number of chiral carbon atoms

Case - 2 When the molecule is unsymmetrical and number of chiral carbon = even number

Number of d and ℓ isomers = $2^{(n-1)}$
Number of meso isomers = $2^{(n/2-1)}$
Total number of optical isomers = $2^{(n-1)} + 2^{\left(\frac{n}{2}-1\right)}$

Case -3 When the molecule is sysmmetrical number of chiral carbon = odd number

Number of d and ℓ isomers = $2^{(n-1)} - 2^{\frac{(n-1)}{2}}$

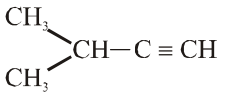
SOLVED EXAMPLE

Ex. 1 The possible number of alkynes with the formula C_5H_8 is -

(A) 2 **(B)** 3

(C) 4 **(D)** 5

Sol. **(B)** $CH_3CH_2CH_2C\equiv CH$



$CH_3CH_2C\equiv CCH_3$

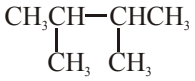
Ex. 2 How many chain isomers can be obtained form the alkane C_6H_{14} is -

(A) 4 **(B)** 5

(C) 6 **(D)** 7

Sol. **(B)** $CH_3CH_2CH_2CH_2CH_2CH_3$ $CH_3CHCH_2-CH_2CH_3$ (CH_3 branch)

(i) **(ii)**



(iii)

Ex. 3 An alkane can show structural isomerism if it has ..... number of minimum carbon atoms –

(A) 1 **(B)** 2

(C) 3 **(D)** 4

Sol. **(D)** CH_4, CH_3-CH_3, $CH_3-CH_2-CH_3$ exist only in one structural form, while $CH_3CH_2CH_2CH_3$ can exist in more than one structure form.

Ex. 4 The molecular formula of a saturated compound is $C_2H_4Cl_2$. The formula permits the existence of two

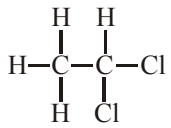
(A) functional isomers

(B) Position isomers

(C) Optical isomers

(D) cis-trans isomers

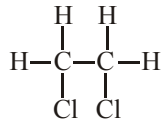
Sol. **(B)** **(i)**



Both are position isomers

1,1-dichloro ethane

(ii)



1,2-dichloro ethane

Ex. 5 Evaporation of an aqueous solution of ammonium cyanate gives urea. This reaction follows the class of -

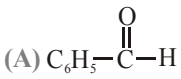
(A) Polymerization **(B)** Isomerization

(C) Association **(D)** Dissociation

Sol. **(B)** $NH_4CNO \xrightarrow{heat} H_2N-CO-NH_2$

Ex. 6 Keto-enol tautomerism is observed in -

(A)



(B)

(C)

(D)

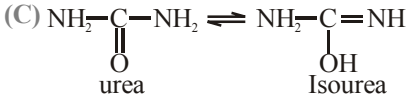
Sol. **(B)** Only compound **(B)** contains α hydrogen atom for showing keto enol tautomerism.

Ex. 7 The type of isomerism found in urea molecule is -

(A) Chain **(B)** Position

(C) Tautomerism **(D)** None of these

Sol. **(C)**



urea Isourea

Ex. 8 How many isomers of $C_5H_{11}OH$ will be primary alcohols -

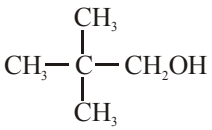
(A) 2 **(B)** 3

(C) 4 **(D)** 5

Sol. **(C)** $CH_3CH_2CH_2CH_2CH_2OH$ $CH_3CHCH_2CH_2OH$ (CH_3 branch)

(i) **(ii)**

$HOCH_2-CHCH_2CH_3$ (CH_3 branch)



(iii) **(iv)**

Ex. 9 Which of the following is an isomer of diethyl ether

(A) $(CH_3)_3COH$ **(B)** CH_3CHO

(C) C_3H_7OH **(D)** $(C_2H_5)_2CHOH$

Sol. **(A)** Diethyl ether has 4 carbon atoms, among different alternative alcohols only $(CH_3)_3COH$ has 4 carbon atoms.

Exercise # 1 SINGLE OBJECTIVE NEET LEVEL

1. In ethane and cyclohexane which one of the following pairs of conformations are more stable
(A) Eclipsed and chair conformations
(B) Staggered and chair conformations
(C) Staggered and boat conformations
(D) Eclipsed and boat conformations

2. Which of the following may exist in enantiomorphs

(A) $CH_3-\underset{\displaystyle CH_3}{\underset{|}{CH}}-COOH$

(B) $CH_2=CHCH_2CH_2CH_3$

(C) $CH_3-\underset{\displaystyle NH_2}{\underset{|}{CH}}-CH_3$

(D) $CH_3-CH_2-\underset{\displaystyle NH_2}{\underset{|}{CH}}-CH_3$

3. Which of the following compounds may not exist as enantiomers
(A) $CH_3CH(OH)CO_2H$
(B) $CH_3CH_2CH(CH_3)CH_2OH$
(C) $C_6H_5CH_2CH_3$
(D) $C_6H_5CHClCH_3$

4. Number of isomers of molecular formula $C_2H_2Br_2$ are
(A) 1 (B) 2
(C) 3 (D) 0

5. Lactic acid shows which type of isomerism
(A) Geometrical isomerism (B) Tautomerism
(C) Optical isomerism (D) Metamerism

6. Which one of the following is an optically active compound
(A) n-propanol (B) 2-chlorobutane
(C) n-butanol (D) 4-hydroxyheptane

7. Compounds with same molecular formula but different structural formulae are called
(A) Isomers (B) Isotopes
(C) Isobars (D) Isoelectronic

8. Which one of the following compounds shows optical isomerism
(A) $CH_3CHCl-CH_2-CH_3$
(B) $CH_3-CH_2-CHCl-CH_2-CH_3$
(C) $ClCH_2-CH_2-CH_2-CH_3$
(D) $ClCH_2-CH_2-CH_3$

9. Which one of the following objects is 'achiral'
(A) Letter P (B) Letter F
(C) Ball (D) A pair of hand

10. Total number of isomers of a disubstituted benzene compound is
(A) 1 (B) 2
(C) 3 (D) 4

11. Separating of d and l enantiomorphs from a racemic mixture is called
(A) Resolution
(B) Dehydration
(C) Rotation
(D) Dehydrohalogenation

12. Number of optical isomers of lactic acid are
(A) 1 (B) 2
(C) 3 (D) 4

13. Which one of the following contains asymmetric carbon atom

(A) $H-\underset{\displaystyle H}{\underset{|}{C}}(Cl)-\underset{\displaystyle H}{\underset{|}{C}}(Br)-H$

(B) $H-\underset{\displaystyle H}{\underset{|}{C}}(Cl)-\underset{\displaystyle H}{\underset{|}{C}}-Cl$

(C) $H-\underset{\displaystyle H}{\underset{|}{C}}(H)-\underset{\displaystyle H}{\underset{|}{C}}-H$

(D) $H-\underset{\displaystyle Br}{\underset{|}{C}}(H)-\underset{\displaystyle OH}{\underset{|}{C}}-CH_3$

14. n-butane and isobutane are examples of
(A) Chain isomers (B) Geometrical isomers
(C) Position isomers (D) Tautomers

15. Which of the following has chiral structure

(A) $CH_3-\underset{\displaystyle CH_3}{\underset{|}{CH}}-CH_2COOH$

(B) $CH_3-CH=CH-CH_3$

(C) $CH_3-\underset{\displaystyle CH_3}{\underset{|}{CH}}-CH_2OH$

(D) $CH_3-CHOH-CH_2CH_3$

Exercise # 2

SINGLE OBJECTIVE | AIIMS LEVEL

1. The number of enantiomers of the compound $CH_3CHBrCHBrCOOH$ is
(A) 0 (B) 1
(C) 3 (D) 4

2. $C_6H_5C \equiv N$ and $C_6H_5N \equiv C$ exhibit which type of isomerism
(A) Position (B) Functional
(C) Dextro isomerism (D) Metamerism

3. Which of the following compounds is not chiral
(A) $DCH_2CH_2CH_2Cl$ (B) CH_3CH_2CHDCl
(C) $CH_3CHDCH_2CH_2Cl$ (D) $CH_2CHClCH_2D$

4. cis and trans 2-butene are
(A) Conformational isomers
(B) Optical isomers
(C) Position isomers
(D) Geometrical isomers

5. Which one of the following is the chiral molecule
(A) CH_3Cl (B) CH_2Cl_2
(C) $CHBr_3$ (D) CHClBrI

6. Cyanide and isocyanide are isomers of type
(A) Positional (B) Functional
(C) Tautomer (D) Structural

7. Glucose and fructose are
(A) Optical isomers (B) Functional isomers
(C) Position isomers (D) Chain isomers

8. Which of the following compounds which is an optically active compound
(A) 1-butanol (B) 2-butanol
(C) 3-butanol (D) 4-heptanol

9. d-tartaric acid and l-tartaric acid are
(A) Enantiomers (B) Tautomers
(C) Diastereoisomers (D) Structural isomers

10. Which of the following statements is not true about enantiomers
(A) They have same physical properties
(B) They have different biological properties
(C) They have same chemical properties towards chiral compounds
(D) None of these

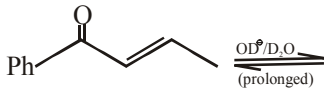
11. Meso-tartaric acid is
(A) Optically inactive
(B) Optically active because of molecular symmetry
(C) Optically inactive due to external compensation
(D) Optically active because of asymmetric carbon atom

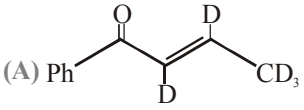
12. The number of possible isomers of the compound with molecular formula C_7H_8O is
(A) 3 (B) 5
(C) 7 (D) 9

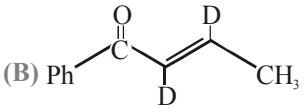
13. The number of isomers for the compound with molecular formula $C_2BrClFI$ is
(A) 3 (B) 4
(C) 5 (D) 6

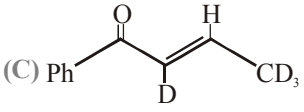
14. Hydrogenation of the adjoining compound in the presence of poisoned palladium catalyst gives
(A) An optically active compound
(B) An optically inactive compound
(C) A racemic mixture
(D) A diastereomeric mixture

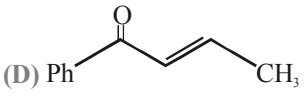
15. How many structural isomer are possible when one of the hydrogen is replaced by a chlorine atom in anthracene?
(A) 3 (B) 7
(C) 4 (D) 6

16.  (P) final product is ?

(A) 

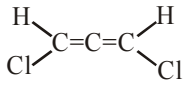
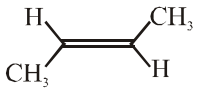
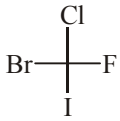
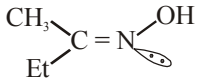
(B) 

(C) 

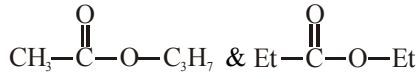
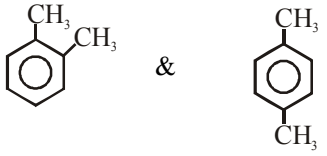
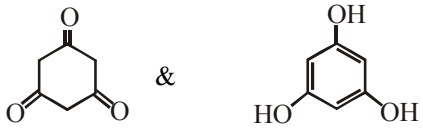
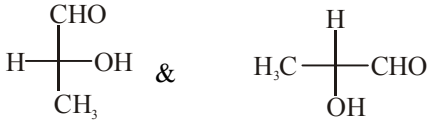
(D) 

Exercise # 3 PART - 1 MATRIX MATCH COLUMN

1. Match the following compounds of column I with column II.

Column - I (Molecule)	Column -I I (Property)
(A) 	(p) Chiral compound
(B) 	(q) Presence of stereocenter
(C) 	(r) Optically active compound
(D) 	(s) Compound containing plane of symmetry

2. Match Column I with Column II :

Column - I	Column -II
(A) 	(p) Enantiomer
(B) 	(q) Positional isomers
(C) 	(r) Metamers
(D) 	(s) Tautomers

Exercise # 4 PART - 1 PREVIOUS YEAR (NEET/AIPMT)

1. But-2-ene exhibits cis-trans-isomerism due to [CBSE AIPMT 2000]
(A) rotation around $C_2 - C_3$ double bond
(B) rotation around $C_3 - C_4$ sigma bond
(C) rotation around $C_1 - C_2$ bond
(D) restricted rotation around C = C bond

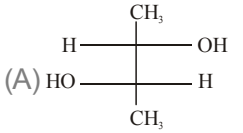
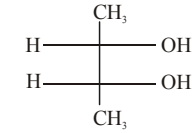
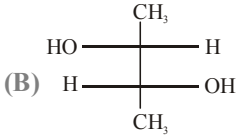
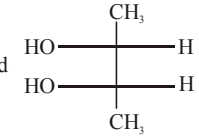
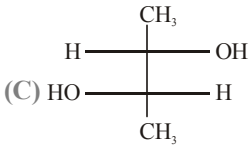
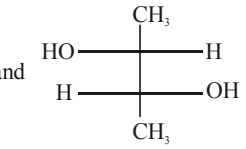
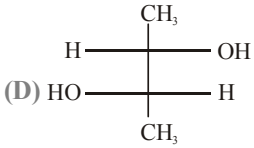
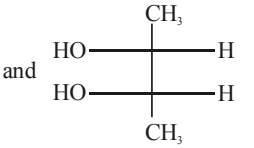
2. The (R) - and (S) - enantiomers of an optically avitve compound differ in [CBSE AIPMT 2000]
(A) their solubility in a chiral solvent
(B) their reactivity with a chiral reagent
(C) their optical rotation of plane polarised light
(D) their melting points

3. A compound of molecular formula C_7H_{16} show optical isomerism, compound will be [CBSE AIPMT 2001]
(A) 2, 3-dimethyl pentane
(B) 2, 2-dimethyl butane
(C) 2-methyl hexane
(D) None of the above

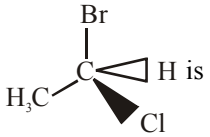
4. $CH_3 - CH_2 - \underset{Cl}{CH} - CH_3$ obtained by chlorination of n-butane, will be [CBSE AIPMT 2001]
(A) meso from (B) racemic mixture
(C) d-form (D) l-form

5. $\overset{\ominus}{\ddot{C}}H_2 - \underset{\underset{O}{\|}}{C} - CH_3$ and $CH_2 = \underset{\underset{:\ddot{O}:}{|}}{C} - CH_3$ are
(A) resonating structures
(B) tautomers
(C) geometrical is isomers
(D) optical isomers

6. Geometrical isomers differ in [CBSE AIPMT 2002]
(A) position of functional group
(B) position of atoms
(C) spatial arrangement of atoms
(D) length of carbon chain

7. Which of the following pair of compounds are enantiomers? [CBSE AIPMT 2003]
(A)  and 
(B)  and 
(C)  and 
(D)  and 

8. Which one of the following pairs represents stereoisomerism? [CBSE AIPMT 2005]
(A) Chain isomerism and rotational isomerism
(B) Structural isomerism and geometrical isomerism
(C) Linkage isomerism and geometrical isomerism
(D) Optical isomerism and geometrical isomerism

9. The chirality of the compound [CBSE AIPMT 2005]

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

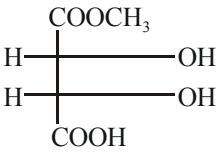
10. Which of the following is not chiral? [CBSE AIPMT 2006]
(A) 2-butanol
(B) 2, 3-dibromo pentane
(C) 3-bromo pentane
(D) 2-hydroxy propanioc acid

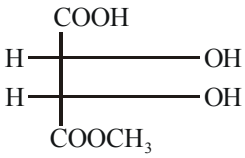
11. If there is no rotation of plane polarised light by a compound in a specific solvent, though to be chiral, it may mean that [CBSE AIPMT 2007]
(A) the compound is certainly a chiral
(B) the compound is certainly meso
(C) there is no compound in the solvent
(D) the compound may be a racemic mixture

MOCK TEST

1. Dimethyl ether and ethyl alcohol are
(A) Metamers (B) Homologues (C) Functional isomers (D) Position isomers

2. The correct statement about the compounds A and B is

(A) 

(B) 

(A) A and B are identical (B) A and B are diastereomers
(C) A and B are enantiomers (D) None of these

3. Ethyl acetoacetate shows, which type of isomerism
(A) Chain (B) Optical (C) Metamerism (D) Tautomerism

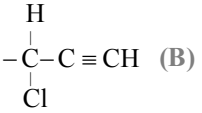
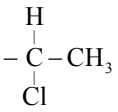
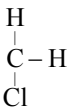
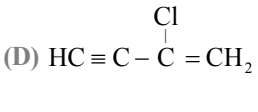
4. Which of the following will have a mesoisomer also
(A) 2, 3-Dichloropentane (B) 2, 3-Dichlorobutane (C) 2-Chlorobutane (D) 2-Hydroxypropanoic acid

5. For which of the following parameters the structural isomers C_2H_5OH and CH_3OCH_3 would be expected to have the same values ? (Assume ideal behaviour)
(A) Boiling points
(B) Vapour pressure at the same temperature
(C) Heat of vaporization
(D) Gaseous densities at the same temperature and pressure

6. Which of the following compounds will exhibit cis-trans isomerism
(A) 2-butene (B) 2-butyne (C) 2-butanol (D) Butanone
(E) Butanol

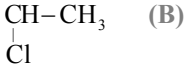
7. Which of the following compounds exhibit stereoisomerism
(A) 2-methyl-butane I (B) 3-methyl-butanoic acid
(C) 3-methyl-butyne I (D) 2-methyl butanoic acid

8. Which of the following is most likely to show optical isomerism

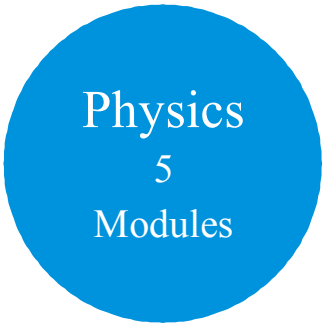
(A)  (B)  (C)  (D) 

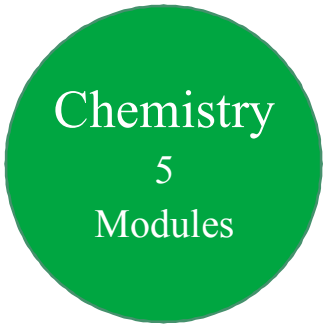
9. Nitroethane can exhibit one of the following kind of isomerism
(A) Metamerism (B) Optical activity (C) Tautomerism (D) Position isomerism

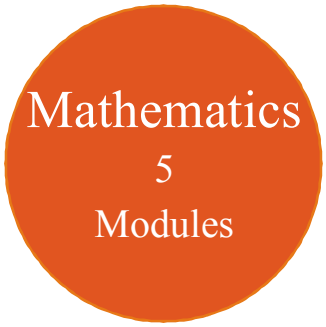
10. $CH_3CH(OH).COOH$ shows
(A) Geometrical isomerism (B) Optical isomerism (C) Both (D) None

11. Which will have enantiomer
(A)  (B) $CH_2CH_2CH_2CH_2Cl$ (C) $CH_3CH_2CH_2CHCl_2$ (D) None

11th Class Modules Chapter Details







PHYSICS

Module-1

1. Physical World & Measurements
2. Basic Maths & Vector
3. Kinematics

Module-2

1. Law of Motion & Friction
2. Work, Energy & Power

Module-3

1. Motion of system of particles & Rigid Body
2. Gravitation

Module-4

1. Mechanical Properties of Matter
2. Thermal Properties of Matter

Module-5

1. Oscillations
2. Waves

CHEMISTRY

Module-1(PC)

1. Some Basic Conceps of Chemistry
2. Atomic Structure
3. Chemical Equilibrium
4. Ionic Equilibrium

Module-2(PC)

1. Thermodynamics & Thermochemistry
2. Redox Reaction
3. States Of Matter (Gaseous & Liquid)

Module-3(IC)

1. Periodic Table
2. Chemical Bonding
3. Hydrogen & Its Compounds
4. S-Block

Module-4(OC)

1. Nomenclature of Organic Compounds
2. Isomerism
3. General Organic Chemistry

Module-5(OC)

1. Reaction Mechanism
2. Hydrocarbon
3. Aromatic Hydrocarbon
4. Environmental Chemistry & Analysis Of Organic Compounds

BIOLOGY

Module-1

1. Diversity in the Living World
2. Plant Kingdom
3. Animal Kingdom

Module-2

1. Morphology in Flowering Plants
2. Anatomy of Flowering Plants
3. Structural Organization in Animals

Module-3

1. Cell: The Unit of Life
2. Biomolecules
3. Cell Cycle & Cell Division
4. Transport in Plants
5. Mineral Nutrition

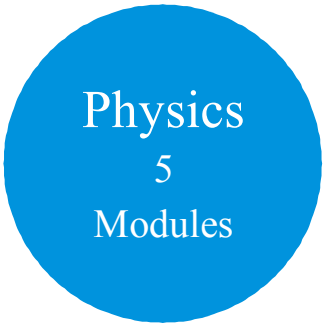
Module-4

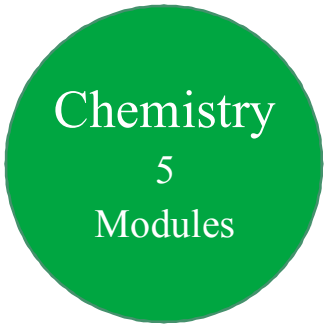
1. Photosynthesis in Higher Plants
2. Respiration in Plants
3. Plant Growth and Development
4. Digestion & Absorption
5. Breathing & Exchange of Gases

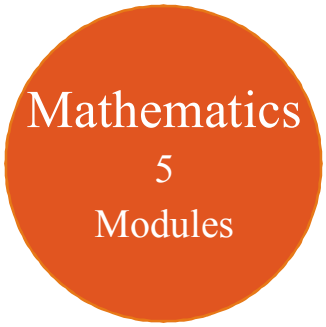
Module-5

1. Body Fluids & Its Circulation
2. Excretory Products & Their Elimination
3. Locomotion & Its Movement
4. Neural Control & Coordination
5. Chemical Coordination and Integration

12th Class Modules Chapter Details







PHYSICS

Module-1

1. Electrostatics
2. Capacitance

Module-2

1. Current Electricity
2. Magnetic Effect of Current and Magnetism

Module-3

1. Electromagnetic Induction
2. Alternating Current

Module-4

1. Geometrical Optics
2. Wave Optics

Module-5

1. Modern Physics
2. Nuclear Physics
3. Solids & Semiconductor Devices
4. Electromagnetic Waves

CHEMISTRY

Module-1(PC)

1. Solid State
2. Chemical Kinetics
3. Solutions and Colligative Properties

Module-2(PC)

1. Electrochemistry
2. Surface Chemistry

Module-3(IC)

1. P-Block Elements
2. Transition Elements (d & f block)
3. Co-ordination Compound
4. Metallurgy

Module-4(OC)

1. HaloAlkanes & HaloArenes
2. Alcohol, Phenol & Ether
3. Aldehyde, Ketone & Carboxylic Acid

Module-5(OC)

1. Nitrogen & Its Derivatives
2. Biomolecules & Polymers
3. Chemistry in Everyday Life

BIOLOGY

Module-1

1. Reproduction in Organisms
2. Sexual Reproduction in Flowering Plants
3. Human Reproduction
4. Reproductive Health

Module-2

1. Principles of Inheritance and Variation
2. Molecular Basis of Inheritance
3. Evolution

Module-3

1. Human Health and Disease
2. Strategies for Enhancement in Food Production
3. Microbes in Human Welfare

Module-4

1. Biotechnology: Principles and Processes
2. Biotechnology and Its Applications
3. Organisms and Populations

Module-5

1. Ecosystem
2. Biodiversity and Conservation
3. Environmental Issues