

Naming organic compounds and their isomers

Chemistry grades 11-12 (A Level · IB · Class 11-12) · Lesson

Quick answer: IUPAC nomenclature names an organic compound from its longest carbon chain, its functional group and its substituents, with numbers giving their positions. Isomers share a molecular formula: structural isomers differ in bonding, while stereoisomers, either E/Z or optical, differ only in the arrangement of atoms in space.

Level: Chemistry grades 11-12 (A Level · IB · Class 11-12) · **Curriculum:** IB S3.2

How do you name an organic compound?

The IUPAC system builds a name from a stem, a suffix and prefixes. First find the longest carbon chain that contains the principal functional group. The chain length gives the stem: meth (1), eth (2), prop (3), but (4), pent (5), hex (6). Number the chain from the end that gives the lowest locant to the principal group, then to double bonds, then to substituents. Write substituents as prefixes in alphabetical order with their locants, using di, tri or tetra for repeats.

Family	Group	Ending or prefix	Example
Alkane	C-C	-ane	pentane
Alkene	C=C	-ene	but-2-ene
Alcohol	-OH	-ol	propan-2-ol
Aldehyde	-CHO	-al	ethanal
Ketone	C=O in chain	-one	pentan-3-one
Carboxylic acid	-COOH	-oic acid	butanoic acid
Halogenoalkane	-Cl, -Br	chloro-, bromo-	2-bromobutane

Definition

A **homologous series** is a family of compounds with the same functional group and general formula, each member differing from the next by CH_2 .

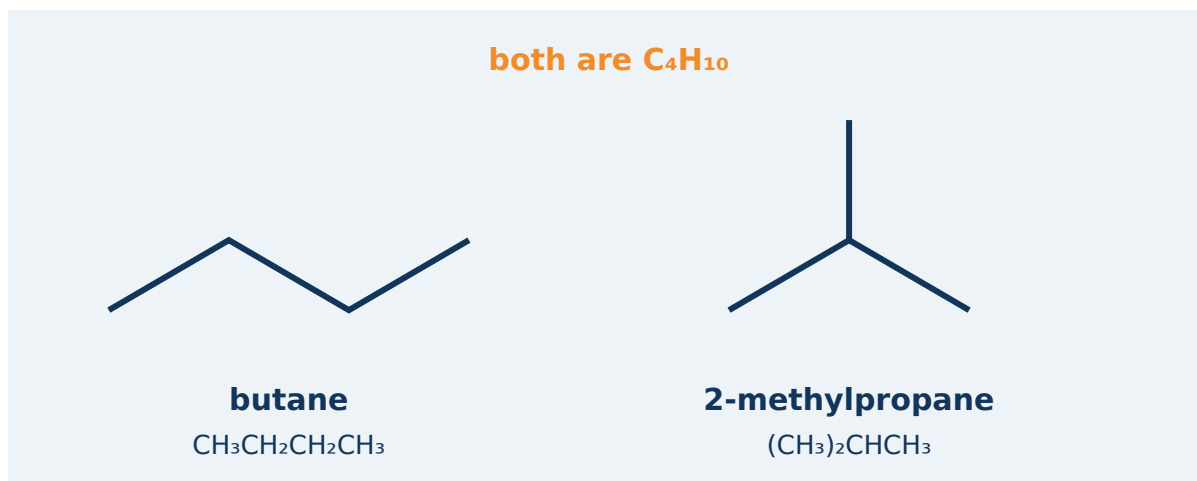
Worked example

Name $\text{CH}_3\text{CH}(\text{CH}_3)\text{CH}_2\text{CH}_2\text{CH}_3$.

The longest chain has five carbons (pentane). A methyl group is on the second carbon when numbered from the left (lowest locant is 2, not 4). Name: **2-methylpentane**.

What is structural isomerism?

Structural isomers have the same molecular formula but different arrangements of atoms. There are three types: chain isomers (different carbon skeleton), position isomers (same skeleton, group on a different carbon) and functional group isomers (different functional groups). Pentane, 2-methylbutane and 2,2-dimethylpropane are the three chain isomers of C_5H_{12} .

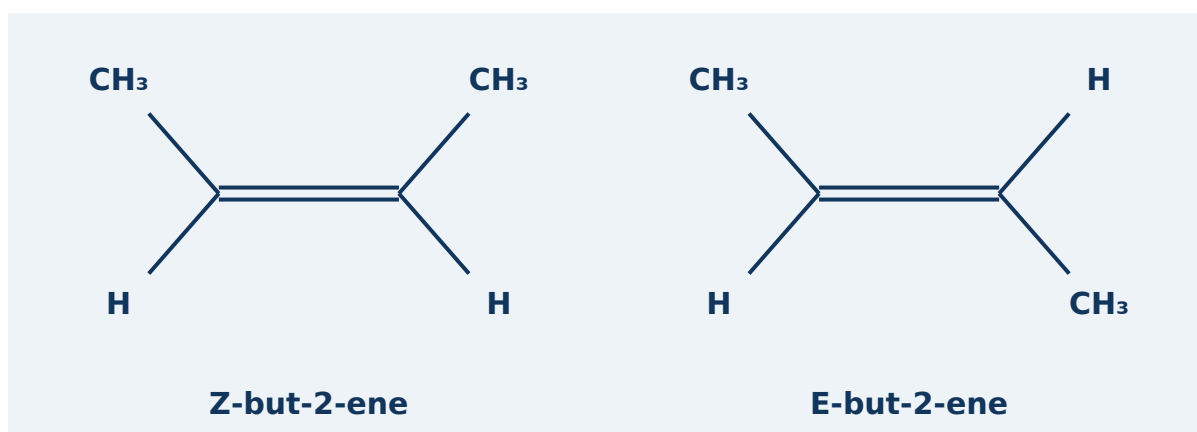


Butane and 2-methylpropane are chain isomers: same molecular formula, different carbon skeleton.

Type	Pair	Formula
Chain	butane and 2-methylpropane	C_4H_{10}
Position	butan-1-ol and butan-2-ol	$C_4H_{10}O$
Functional group	propanal and propanone	C_3H_6O

What is E/Z isomerism?

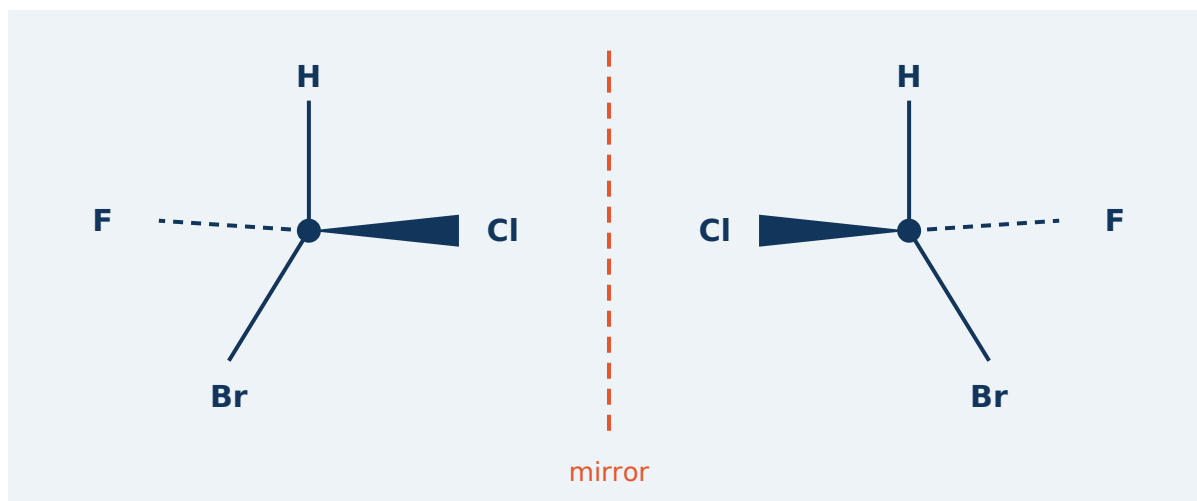
Rotation about a $C=C$ double bond is restricted, so groups attached to it stay fixed in space. E/Z isomers occur when each carbon of the double bond carries two different groups. The groups on each carbon are ranked by the Cahn-Ingold-Prelog rule: the atom with the higher atomic number has higher priority. If the two higher-priority groups are on the same side the isomer is Z (from German *zusammen*, together); if they are on opposite sides it is E (*entgegen*, opposite).



Restricted rotation about $C=C$ gives two stereoisomers: Z (same side) and E (opposite sides).

What are optical isomers?

A carbon atom bonded to four different groups is a chiral centre (stereocentre). A molecule with one chiral centre exists as two enantiomers, which are non-superimposable mirror images. Enantiomers have identical melting points and boiling points but rotate plane-polarised light by equal amounts in opposite directions. An equal mixture is a racemic mixture and has no net rotation.



$CHBrClF$ has four different groups on one carbon, so it exists as two enantiomers that cannot be superimposed.

Worked example

Is butan-2-ol, $CH_3CH(OH)CH_2CH_3$, chiral?

Carbon 2 is bonded to H, OH, CH_3 and CH_2CH_3 , which are four different groups. It is a chiral centre, so the molecule has **two enantiomers**.

Key law

Stereoisomers share the same structural formula. E/Z isomers differ at a double bond, enantiomers differ at a chiral centre. A molecule with n independent chiral centres has up to 2^n stereoisomers.

Common mistake

A carbon with four substituents is not automatically chiral: the four groups must all be different. In propan-2-ol the middle carbon carries two identical methyl groups, so there is no chiral centre. Also, cis and trans describe the same side or opposite sides of identical groups, while E and Z use priority and may not match.

Lina's tip

To find a chiral centre, circle each sp^3 carbon and write the four groups on it. If any two groups match, it is not chiral. To name, always find the longest chain first and number second.

Key points to remember

- Name = prefixes (alphabetical, with locants) + stem + suffix, using the longest chain and lowest locants
- Structural isomers: chain, position, functional group
- E/Z needs restricted rotation and two different groups on each double-bond carbon
- A chiral centre has four different groups; enantiomers rotate light equally in opposite senses
- n chiral centres give up to 2^n stereoisomers

Naming organic compounds and their isomers: frequently asked questions

What is the difference between structural and stereoisomers?

Structural isomers have the same molecular formula but different bonding arrangements. Stereoisomers have the same structural formula but different arrangements of atoms in space, such as E/Z and optical isomers.

How do you decide between E and Z?

Rank the two groups on each carbon of the double bond by atomic number. If the higher-ranked groups lie on the same side it is Z; on opposite sides it is E.

Why do enantiomers rotate plane-polarised light?

Their molecules are chiral, so they interact differently with the rotating electric field of the light. Each enantiomer rotates the plane by the same angle but in opposite directions.

What is a racemic mixture?

It is a 50:50 mixture of two enantiomers. The rotations cancel, so it shows no net optical activity.

How many chain isomers does C_5H_{12} have?

Three: pentane, 2-methylbutane and 2,2-dimethylpropane. They have the same formula but different carbon skeletons.