Module 3, Lecture 4

Structure and Reactions of Organic Molecules

Part 1 – Stereochemistry
Introduction to Organic Molecules and Isomerism

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References to Brown *et al* text shown in BLUE

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Learning Objectives:

- **understand why organic molecules are important**
- **to have an understanding of the structural representations used in organic chemistry**
- **to have an understanding of what isomers are**
- **to be able to identify *E* or *Z* isomers of alkenes**

Textbook: Chapter 24, Chapter 25, Chapter 26, Brown

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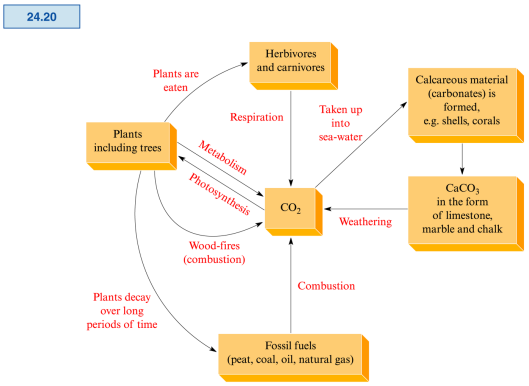
Carbon Compounds (Organic Chemistry)

Introduction (24.1)

Most biological molecules are organic.

In nature, carbon passes from one system to another - the carbon cycle.



Box 24.1 The carbon cycle.

Organic chemistry is also vitally important industrially and commercially as it is very common in every day life,

e.g. Pharmaceuticals

Cosmetics

Plastics

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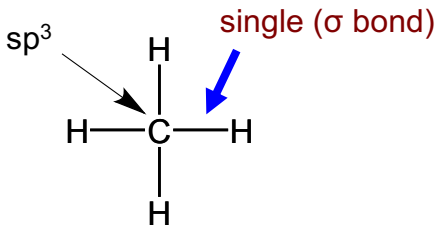
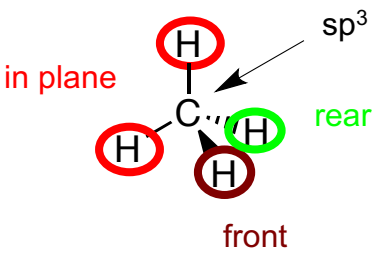
Structural Representation of Organic Molecules (24.1)

Structural drawing of organic molecules:

methane, CH_4, tetrahedral, sp^3 hybridised carbon





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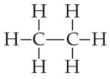
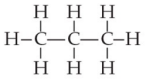
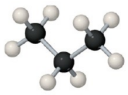
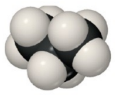
Structural Representation of Organic Molecules (24.1)

Structural drawing of organic molecules:

methane, CH_4, tetrahedral, sp^3 hybridised carbon

TABLE 22.2 • The simplest alkanes

Common name	Structural formula	Condensed structural formula	Ball-and-stick model	Space-filling representation
Methane		CH_4		
Ethane		CH_3CH_3		
Propane		$CH_3CH_2CH_3$		

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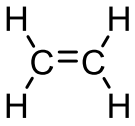
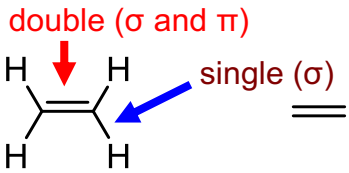
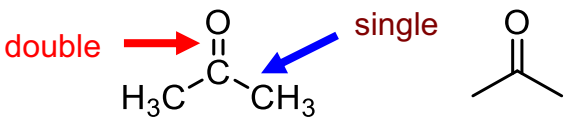
Structural Representation of Organic Molecules (24.1)





ethene (ethylene), C_2H_4



propanone (acetone), C_3H_6O, CH_3COCH_3

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Drawing Organic Structures

- C atoms form the backbone of the molecule
- A position where the atom is not specified is occupied by a C
- Each C atom has four bonds
- If a C atom is drawn with fewer than four bonds the remaining unspecified bonds must be connected to H atoms.

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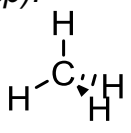
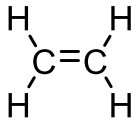
Examples:

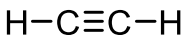
The arrangement of bonds around a C atom may be *tetrahedral* (sp^3), trigonal *planar* (sp^2) or *linear* (*sp*):



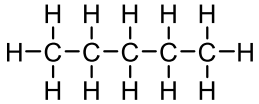
tetrahedral

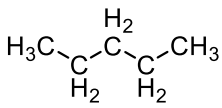


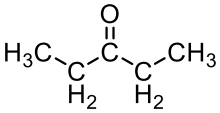
trigonal planar

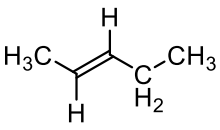


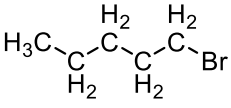
linear

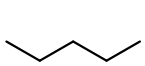


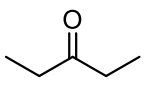


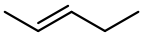


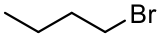












Br

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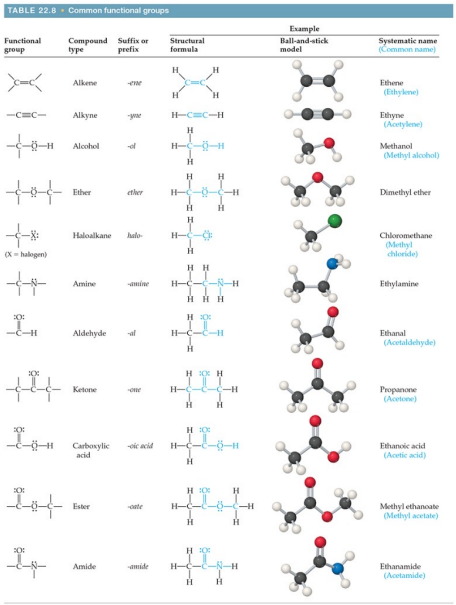
Functional Groups (24.6)

Structural features that give a characteristic reactivity is called a *functional group*.

R-Y

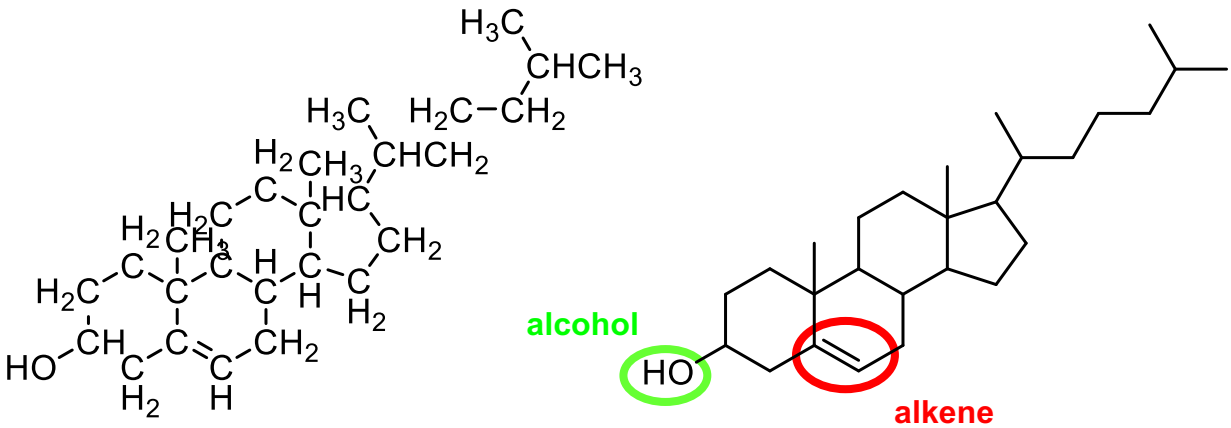
Being able to recognize functional groups and a knowledge of their chemical characteristics is the key to understanding the chemical properties of a particular compound.

More complicated R-Y examples……



R-Y examples……

Cholesterol: a lipid molecule, it is an essential structural component of all animal cell membranes.

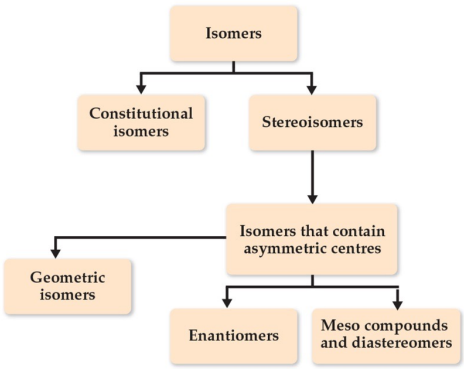


Isomerism (25.3)

Isomers are compounds with the same elements but a different arrangement

Constitutional isomers have different connections of atoms

Stereoisomers are isomers that differ in the arrangement of their atoms in space.



▶ **FIGURE 23.1 There are several different forms of isomerism.** Although constitutional, geometric and diastereomers vary in their physical properties, enantiomers vary only when in a chiral environment.

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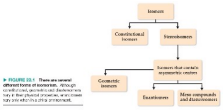
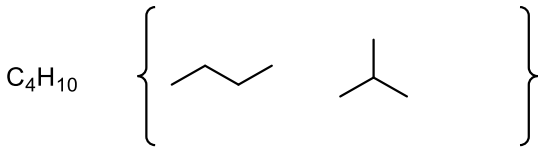
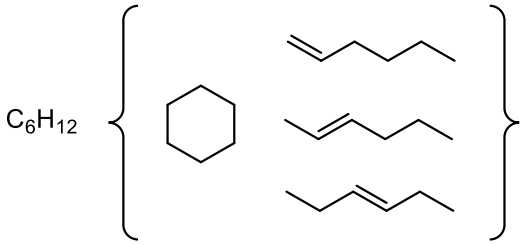


Isomerism…….Same Molecular Formula

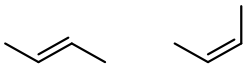
Constitutional isomers have different connections of atoms



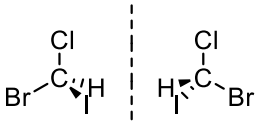


Stereoisomers are isomers that differ in the arrangement of their atoms in space.

Includes:



Diastereomers *E* and *Z*, *cis* and *trans*



Enantiomers *R* and *S, right* and *left* handed

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Stereoisomerism (26.2)

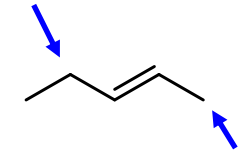
The arrangement of the four groups attached to a C=C bond is fixed.

This may produce two stereoisomers (*E*)- (*Z*)-

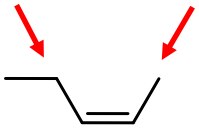
(*Z*)- derived from German zusammen = 'together'
(*E*)- derived from German entgegen = 'opposite' .

(*E*)-isomer *trans*

(*Z*)-isomer *cis*



(*E*)-pent-2-ene



(*Z*)-pent-2-ene

(*note relative positions of H atoms not shown*):

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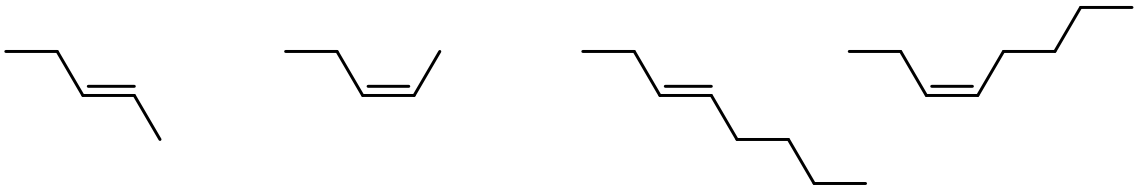
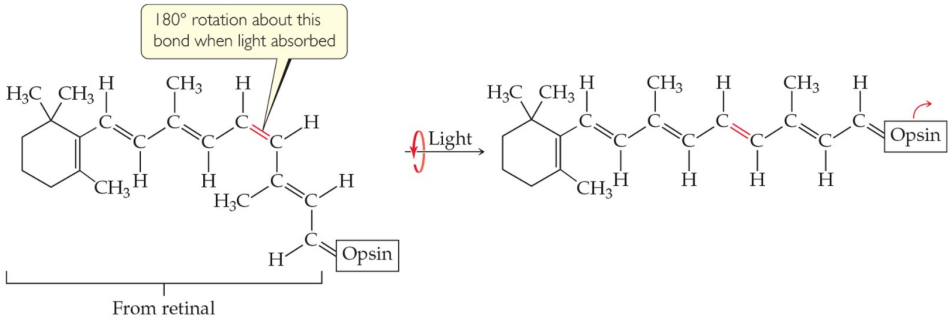
Stereoisomerism……

Examples (*note relative positions of H atoms not shown*):





▲ FIGURE 24.16 **The chemical basis of vision.** When rhodopsin absorbs visible light, the π component of the double bond (shown in red) breaks, allowing rotation that produces a change in molecular geometry.

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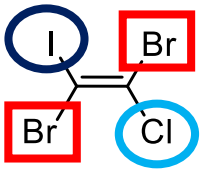
Stereoisomerism…… (Z)- or (E)-isomers

(*Z*)- or (*E*)-relationship between substituents attached to double bonds determined by a *sequence rule of preferred atoms or groups*.

Priorities assigned to groups based on *atomic number*.

Consider the alkene:



Left-hand C atom, I > Br (53 > 35). Right-hand C atom, Br >Cl (35 > 17).

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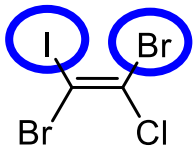
Stereoisomerism…… (Z)- or (E)-isomers

(*Z*)- or (*E*)-relationship between substituents attached to double bonds determined by a *sequence rule of preferred atoms or groups*.

Priorities assigned to groups based on *atomic number*.

Consider the alkene:



Left-hand C atom, I > Br (53 > 35). Right-hand C atom, Br > Cl (35 >17).

(*Z*)-isomer

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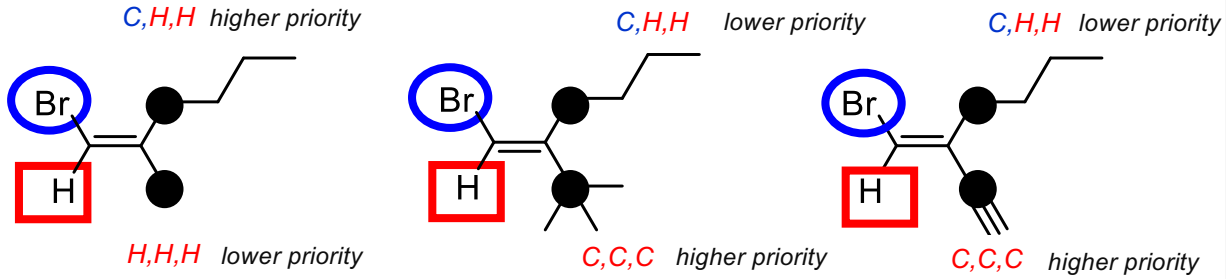
Examples…… (*Z*)- or (*E*)-isomers



Left-hand C atoms, Br > H (35 > 1). Right-hand C atoms, two C atoms are attached.

Consider the next atoms in the groups and assign priorities:

- one atom of higher atomic number takes precedence over several of lower atomic number
- two atoms of a particular atomic number take precedence over one atom of the same atomic number
- double bonds are treated as two single bonds, triple as three single bonds

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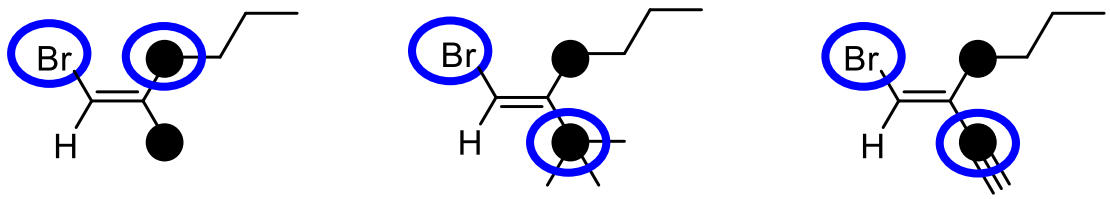
Examples…… (*Z*)- or (*E*)-isomers



(*Z*) - isomer (*E*) - isomer (*E*) - isomer

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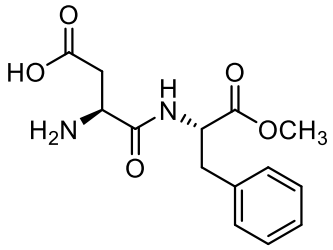
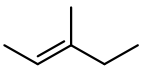
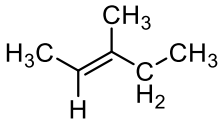
Questions

1. Identify the functional groups in Aspartame (Nutrasweet).

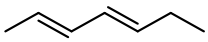


2. Is this alkene the *E* or *Z* isomer?





3. Draw and label (*E/Z*) the other 3 stereoisomers of this (*E,E*)-alkene.



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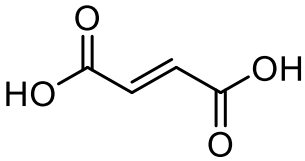
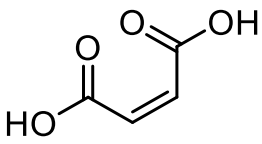
Questions

Maleic acid and Fumaric acid are isomers

Both compounds are active antibacterial agents, but the *Z*-isomer is the most active compound? Identify the *Z*-isomer

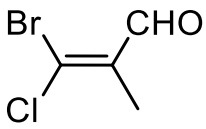


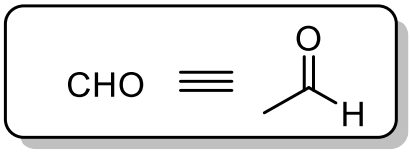
Fumaric acid



Maleic acid

What isomer is the following compound?





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✱ Homework ✱

Chemistry – the central science 15th Ed

Brown et al.

Problem 26.52

Answers on Blackboard

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