

② CARBINOL NAMES

carbinol	methylisopropylcarbinol	ethyl-n-propylcarbinol
ethylcarbinol	isobutylcarbinol	diethylcarbinol
dimethylcarbinol	methylcarbinol	s-butylcarbinol
methylethylcarbinol	trimethylcarbinol	t-butylcarbinol

③ I.U.C. NAMES

ethanol	2-methyl-1-propanol	2,2-dimethyl-1-propanol
1-propanol	2-hexanol	3-pentanol
2-butanol	methanol	2-methyl-2-butanol
2-methyl-2-propanol	2-propanol	3-methyl-1-butanol
3-hexanol	1-butanol	1-hexanol
3-methyl-1-pentanol		



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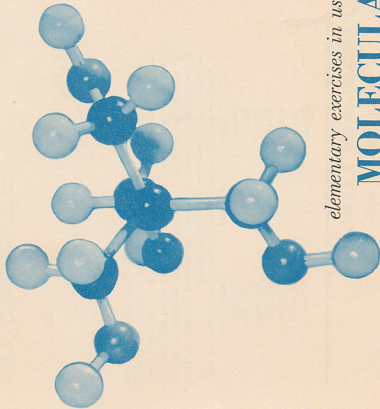
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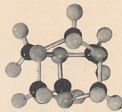
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elementary exercises in use of

**MOLECULAR
MODELS[®]**



MOLECULAR REPRESENTATION

Atoms are represented by colored enameled balls drilled to receive connecting bonds. Carbon to carbon, carbon to nitrogen and other skeleton linkages are represented by 2½ inch slotted wood pegs. Carbon to hydrogen, carbon to chlorine or other substituent univalent groups are represented by 1½ inch slotted pegs. Multiple bonds, ring structure linkage, flexible bonds and unsaturated linkages are represented by 2 inch cadmium plated helical springs.

Components of the set include the following atom-representing balls:

Color	Diameter	Representation
Black	1¾	Carbon
Blue	1¾	Nitrogen
Yellow	1¾	Hydrogen
Red	1¾	Oxygen
Green	1¾	Chlorine
Orange	1¾	Bromine
Purple	1¾	Iodine

PRELIMINARY EXERCISE

The Use of Structural Models

Prepare samples of the following, write their structural formulae in your notebook, and have your instructor approve the completed set of models.



Combinations between two atoms:

- Carbon to Hydrogen. (C-H) (insert small wooden pegs in all holes to indicate unsatisfied bonds)
- Carbon to Carbon (single bond, use longer pegs)
- Carbon to Carbon (two bonds, use springs)
- Carbon to Carbon (three bonds, use springs)
- Carbon to Halogen
- Carbon to Oxygen (single bond)
- Carbon to Oxygen (double bond)

After you have obtained your instructor's approval on part A, part B should be prepared and approved.



Combinations between three atoms:

- Carbon to Carbon to Carbon
- Carbon to Oxygen to Carbon
- Carbon to Oxygen to Hydrogen
- Oxygen to Carbon (double bond) to Oxygen (single bond)

EXERCISE

Homology and Isomerism

- Construct as many models of the methane molecule as possible from your set. *Place these models in a row for reference.* From a second methane molecule remove one of the hydrogen atoms. What is the name of the radical formed? What is its valence?

- Using a third molecule of methane, replace one of the hydrogen atoms by the CH₃ group obtained above. What is the formula for the hydrocarbon which this new structure represents? What is its name? Are all the hydrogen atoms of the new hydrocarbon equivalent? *Place aside this molecular model* and from the remaining methane molecules assemble a second one like it. From the new model remove one of the hydrogen atoms. What is the name of the radical formed? What is its valence? Are all the hydrogen atoms of this radical equivalent?

- Replace the hydrogen atom removed by a methyl group. What is the molecular formula of the hydrocarbon represented by the new structure? What is its name? Are all the hydrogens in this hydrocarbon equivalent? *Place this structure aside* and assemble a second one like it. Remove one of the hydrogen atoms from one of the end carbon atoms of this structure. What is the name of the radical formed? What is its valence? By removing the hydrogen atom from the middle carbon atom would a different radical have been obtained?

- Unite this new radical with a methyl group. What is the molecular formula of the hydrocarbon represented by the new structure? What is its name?

What is the difference in carbon and hydrogen content of the two hydrocarbons formulated in parts 3 and 4? In parts 2 and 3? In parts 3 and 4? A series of compounds differing in this constant difference is called what kind of a series? What is the name and general formula for this series?

Record the answers to each of the above questions in your notebook and tabulate the data indicated by the form given below:

Number	Name of Carbon Hydrocarbon Atoms	Molecular Formula	Difference C and H	Mol. Wt.	Structural Formula	Alkyl Group Name
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- Construct two models of the propane molecule. On one of these models replace a hydrogen from one of the end carbon atoms by a chlorine atom. On the second propane model replace a hydrogen from the middle carbon atom by chlorine. Write the structural formulas of these two compounds. Also write their molecular formulas. Are the two compounds identical? Do they contain the same carbon skeleton? If they are not identical, in what respects do they differ? What term is used to describe this condition when it exists between two compounds?

6 In each of the two models for chloro substituted derivatives of propane obtained above, replace the chlorine atoms by methyl groups. Write the molecular formulas for the two compounds represented. Write their structural formulas. Are these two compounds identical? Do they contain the same carbon skeleton? Does this condition resemble in any way that found between the two chloro propane? In what respects do the two cases differ? Devise terms which will suitably describe these two forms of the phenomenon.

EXERCISE

Structure and Classification of Alcohols

- 1 Construct a model of a molecule of methane. Replace one of the hydrogen atoms by an OH group. Compounds bearing this relationship to a saturated hydrocarbon form what class of organic compounds? What is the characteristic ending for the names of the compounds of this class?
- 2 Set the model aside for reference and construct a second one like it. Replace one of the hydrogen atoms, attached to carbon, by a methyl group. What is the name of the compound represented by the new structure? Write its structural formula. It may be regarded as a derivative of what hydrocarbon? The hydroxy derivative of methane is frequently called methanol. In what sense is this name of nomenclature what would the new compound be called? Set aside this model. Construct a third molecule of hydroxy-methane called *carbinol*. Considering the way in which the molecule was derived from *carbinol*, what would the new compound be called in the same system?
- 3 Place this model aside and construct another one like it. Replace a second hydrogen atom of the *carbinol* group by a methyl group. What is the common name of the compound here represented? Write its structural formula. Of what hydrocarbon is it a derivative? What is its *carbinol* name?
- 4 Place this model aside and construct a second one like it. Replace the third and last hydrogen atom on the original *carbinol* residue by a methyl group. Write the structural formula of this new structure. What is the *carbinol* name of the compound it represents?
- 5 We have before us now the models of four alcohols. Each contains a single hydroxyl group, bonded to carbon. Now, in many hydrogen atoms are attached directly to this associated carbon atom. In what respect regarding the original *carbinol* (hydroxy methane) of which there is only one representative, how many classes of alcohols will we have, based on the nature of the *carbinol* residue or group? Consult your text and give the type of formula and name for each of these classes. Tabulate the data for each of the alcohols formulated above as indicated in the form given below and have your instructor approve both your table and models. Do these alcohols form an homologous series? If so, what is the general formula?

Number Carbon Atoms	Name of Alcohol	Molecular Formula	Difference C and H	Structural Formula	Classi- cation	Carbinol Name
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6 By dismembering the above models, set up the structures for the two isomeric butanes. How many different alcohols may be obtained by replacing a single hydrogen atom in *n*-butane by an hydroxyl group? Record the structural formulas, names, and classification of each. How many different alcohols may be derived from isobutane? Record the structural formula, names, and classification of each. What is the relationship existing among all of these alcohols? Without using the models, work out the structural formulas, names, and classifications of the alcohols in this series containing five carbon atoms.

EXERCISE

Oxidation Products of the Alcohols

Let us suppose each of the alcohols formulated in the preceding exercise were submitted to oxidation and that a hydrogen atom (bound to carbon) of the *carbinol* group were changed to hydroxyl. This carbon atom would now be in combination with two hydroxyl groups. Long experience has shown that such compounds are very unstable, the two hydroxyl groups reacting to split off water, the remaining oxygen atom becoming united with the carbon atom by a double bond. Reassemble each of the alcohols indicated above on the models and make the transformations indicated. Record in your notebook the molecular formulas of both the alcohol and its oxidation product. How do they differ in composition? Compounds having the general formula $R-C(=O)-O$ are called aldehydes and those



having the general formula $R-\overset{\text{H}}{\underset{\text{H}}{\text{C}}}-O$ are called ketones. After your instructor has approved each of the models for the oxidation products, tabulate the data indicated by the following form in your notebook:

Structural Formula Alcohol	Class of Alcohol	Structural Formula of Oxidation Product	Common Name	Derivation Name	I.U.C. Name
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What conclusions may one draw as to the oxidation products of primary, secondary, and tertiary alcohols?

EXERCISE

Organic Nomenclature

Many organic compounds can be named by more than one method. The details of the several methods are fully discussed in the text. The student should strive to become sufficiently familiar with each of these systems of nomenclature so that he can formulate the structure of the compound from its name or name the compound from its structure. The instructor

will indicate a number of compounds in the following lists. The student will then construct a model of each of the compounds indicated. He should tabulate the name of the compound, its plane projection formula and its name according to other systems of nomenclature in his laboratory notebook, in the form given below, and report to his instructor for the approval of both the model and table.

Number Carbon Atoms	Structural Formula	Common Name	Derivation or Carbinol Name	I. U. C. or Rational Name
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The student should be prepared to define and to use correctly in his discussions with his instructor each of the following terms: homologous series, isomerism, substitution, addition, alkyl group, saturated compound, unsaturated compound, paraffin, olefin, acetylene hydrocarbon, double bond, radical, substituent product, addition product, and carinol group.

HYDROCARBONS

1 COMMON NAMES

<i>n</i> -pentane	ncopentane	ethane
propylene	methane	butylene
propane	acetylene	isopentane
isobutylene	isobutane	isohexane
<i>n</i> -butane	ethylene	

2 DERIVATION NAMES

methylacetylene	<i>sym</i> -dimethylethylene	tetramethylmethane
trimethylmethane	methylmethane	dimethylacetylene
ethylacetylene	ethylethylene	dimethylethylmethane
trimethylacetylene	dimethylmethane	triethylmethane
dimethylacetylene	<i>unsym</i> -dimethylethylene	

③ I.U.C. NAMES

ethane	1-hexene
ethane	2-methyl-1-butene
ethane	2-methyl-2-butene
propane	3-hexene
propane	3-methyl-1-butene
propene	1,3-butadiene
propene	1,4-pentadiene
butane	pentene
2-methylbutane	1-pentene
2-methylpentane	2-pentene
3-methylpentane	2-hexene
	2-octene

HYDROCARBON RADICALS -ALKYL GROUPS

ethyl	methyl	<i>n</i> -hexyl
<i>n</i> -propyl	isoamyl	neopentyl
isobutyl	<i>n</i> -butyl	<i>i</i> -butyl
isopropyl	<i>n</i> -amyl	<i>t</i> -butyl

HALOGEN SUBSTITUTION AND ADDITION PRODUCTS

trichloromethane
ethyl bromide
1,1-dichloropropane
1,1-dichloroethane
1,2,3,4-tetrachlorobutane
2-bromopropane
2,3-dibromobutane
methyl chloride
methylene chloride
carbon tetrachloride
dichloromethane
2-bromo-1-butene
1,2-dichloroethane
tetrachloromethane
chloroform
2-iodo-3-bromobutane
2-bromopropane
n-propyl iodide
1,4-dibromobutane
3-chloropentane
2-dibromoethane
ethylene bromide
ethyl bromide
isopropyl bromide

ALCOHOLS

1 COMMON NAMES

methyl alcohol	<i>s</i> -butyl alcohol	isobutyl alcohol
<i>n</i> -butyl alcohol	ethyl alcohol	isoamyl alcohol
isopropyl alcohol	<i>n</i> -propyl alcohol	<i>t</i> -butyl alcohol
<i>n</i> -amyl alcohol		