Welcome to 3.091

Lecture 27

November 16, 2009

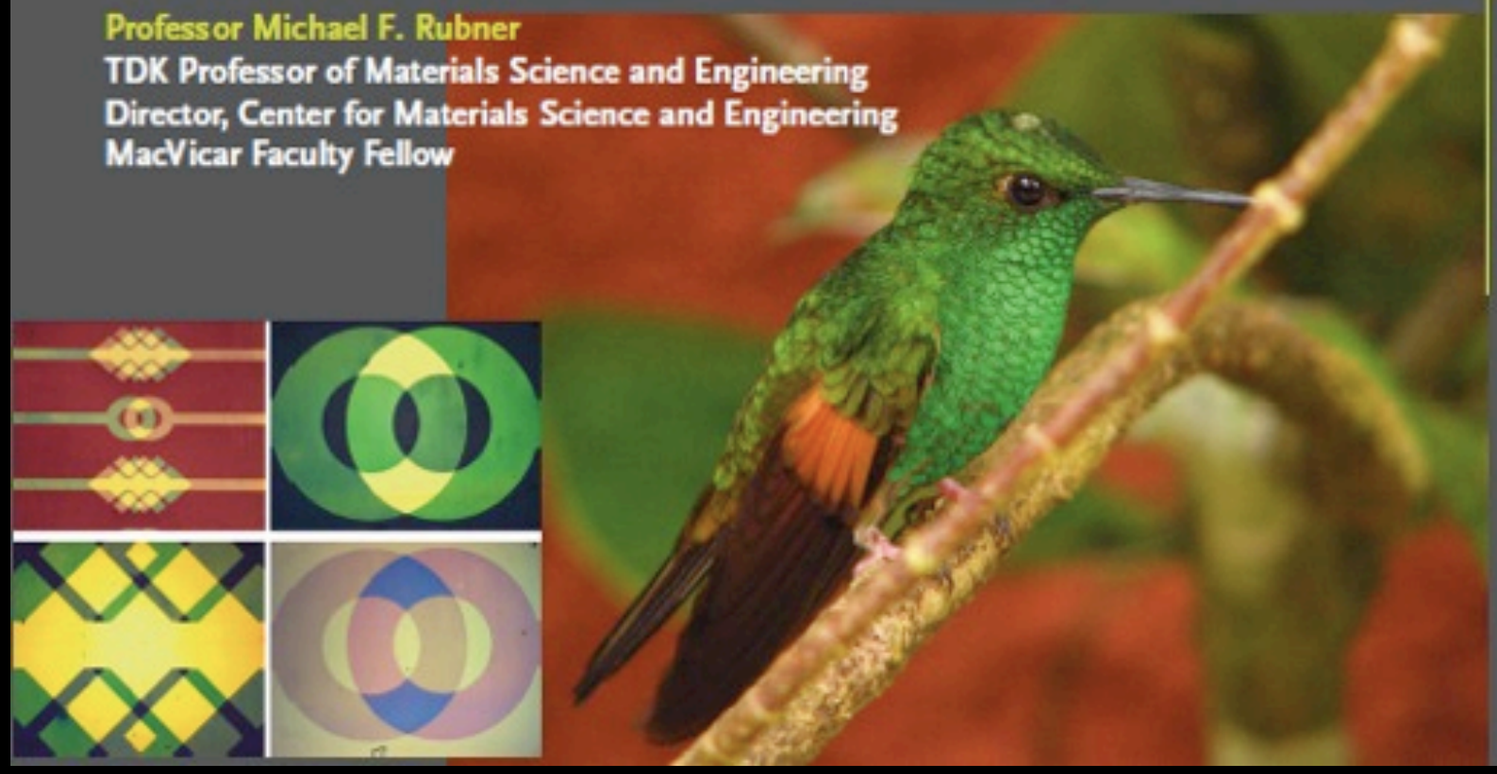
Introduction to Organic Chemistry

Fall 2009 Wulff Lecture

Tuesday, November 17, 2009
4:00–5:00 pm
Room 10-250
Reception immediately following

Nature Inspired Materials Science

Professor Michael F. Rubner
TDK Professor of Materials Science and Engineering
Director, Center for Materials Science and Engineering
MacVicar Faculty Fellow



More and more, materials scientists are looking to nature to find clues to create highly functional materials with exceptional properties. The fog-harvesting capabilities of the Namib Desert beetle, the iridescent colors of the hummingbird, and the super-water-repellant abilities of the lotus leaf are a few examples of the amazing properties found in the natural world. This lecture explores synthetic mimics to the nano- and micro-structures responsible for these properties with many potential applications.

The Wulff Lecture is an introductory, general-audience, entertaining lecture which serves to educate, inspire, and encourage MIT undergraduates to take up study in the field of materials science and engineering and related fields. The entire MIT community, particularly freshmen, is invited to attend. The Wulff Lecture honors the late Professor John Wulff, a skilled, provocative, and entertaining teacher who inaugurated a new approach to teaching the popular freshman subject: 3.091 Introduction to Solid State Chemistry.

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3.091 Test #3
“celebration part 3”
Monday, November 23, 2009

Makeup test December 2 during class

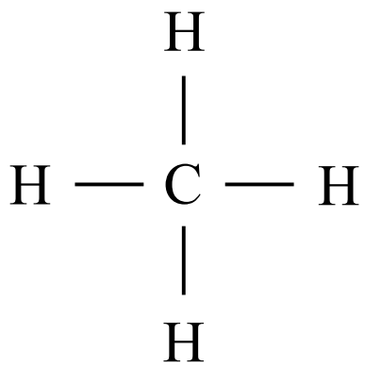
Still image from film *Ghostbusters* removed due to copyright restrictions.

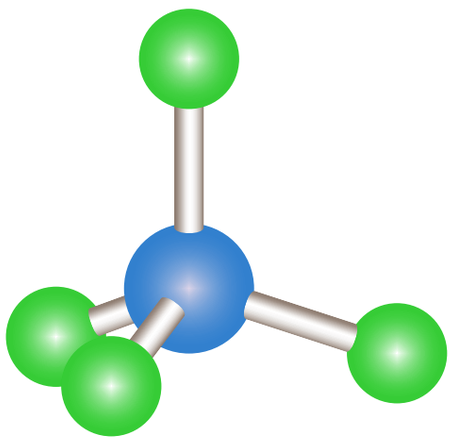
taxonomy of hydrocarbons

alkanes	*alkenes*	*alkynes*
sp^3 –	**sp^2 =**	**sp ≡**
☞ σ	☞ σ,π	☞ σ,π
sat^d	$unsat^d$	$unsat^d$
C_nH_{2n+2}	C_nH_{2n}	C_nH_{2n-2}
C_2H_6	C_2H_4	C_2H_2
ethane	ethene ethylene	ethyne acetylene
$-C_2H_5$	$-C_2H_3$	
ethyl	vinyl	

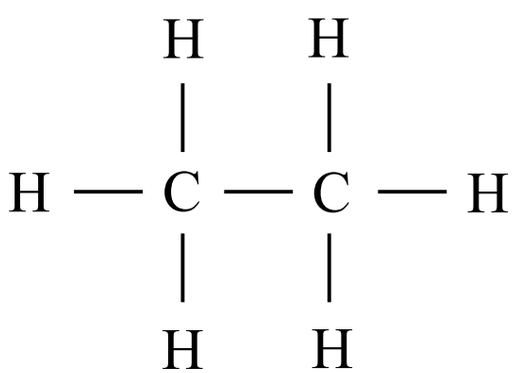
The Saturated Hydrocarbons, or Alkanes

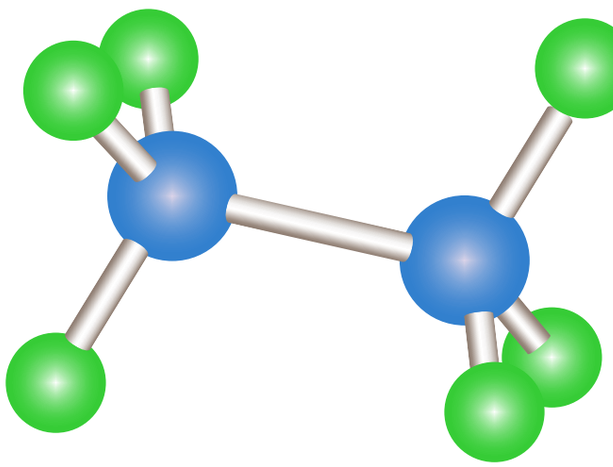
Name	Molecular Formula	Melting Point (^oC)	Boiling Point (^oC)	State at 25^oC
Methane	CH_4	-182.5	-164	Gas
Ethane	C_2H_6	-183.3	-88.6	Gas
Propane	C_3H_8	-189.7	-42.1	Gas
Butane	C_4H_{10}	-138.4	-0.5	Gas
Pentane	C_5H_{12}	-129.7	36.1	Liquid
Hexane	C_6H_{14}	-95	68.9	Liquid
Heptane	C_7H_{16}	-90.6	98.4	Liquid
Octane	C_8H_{18}	-56.8	124.7	Liquid
Nonane	C_9H_{20}	-51	150.8	Liquid
Decane	$C_{10}H_{22}$	-29.7	174.1	Liquid
Undecane	$C_{11}H_{24}$	-24.6	195.9	Liquid
Dodecane	$C_{12}H_{26}$	-9.6	216.3	Liquid
Eicosane	$C_{20}H_{42}$	36.8	343	Solid
Triacontane	$C_{30}H_{62}$	65.8	449.7	Solid



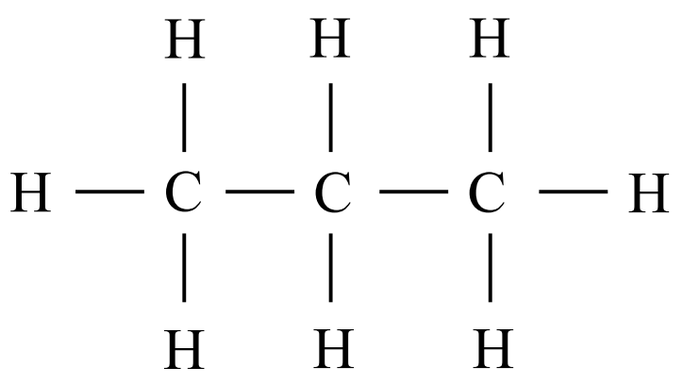


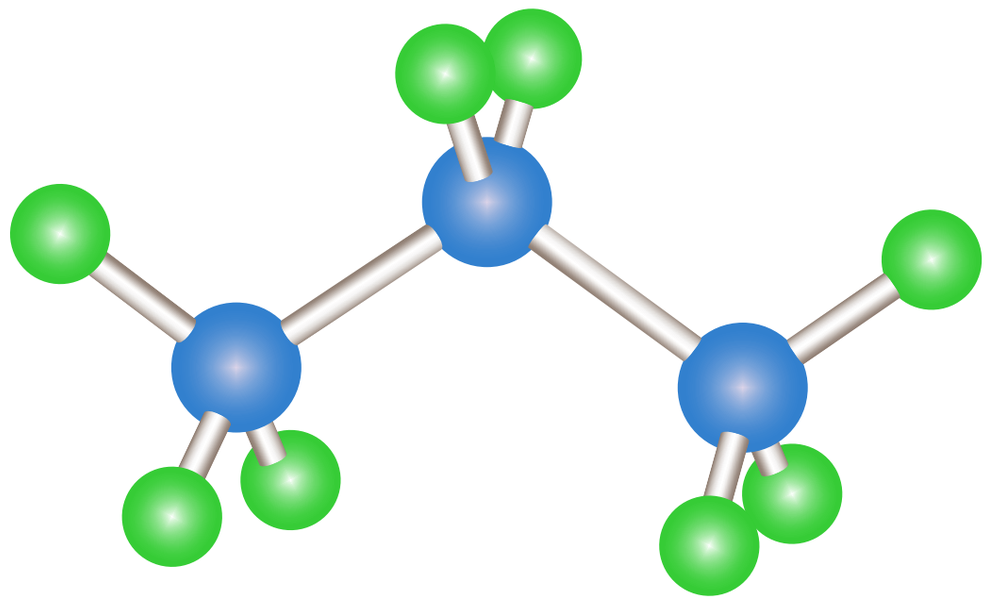
Methane, CH_4





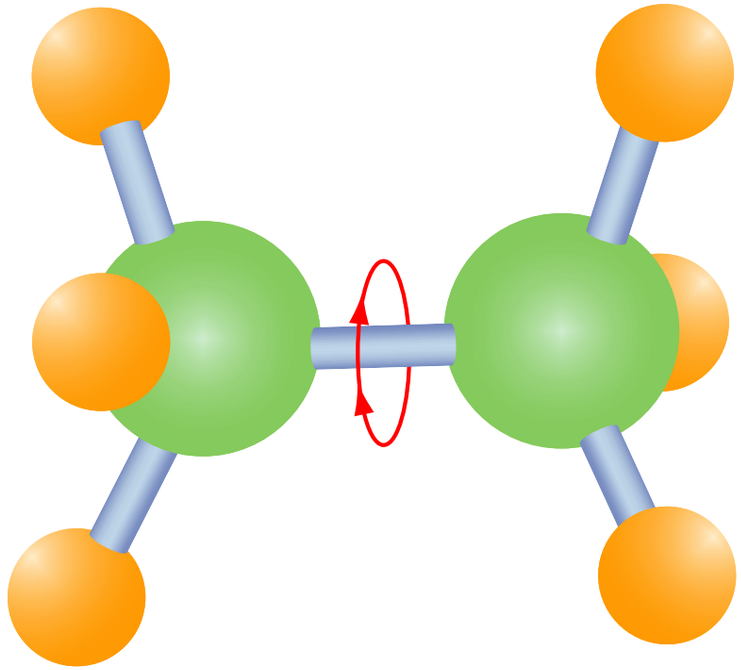
Ethane, C_2H_6

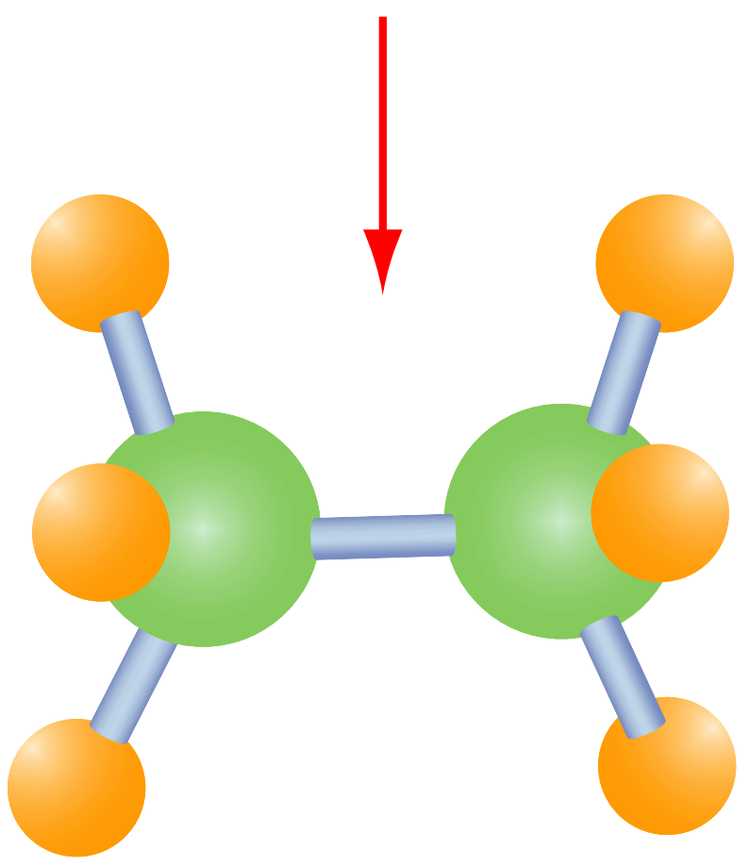




Propane, C_3H_8

Staggered

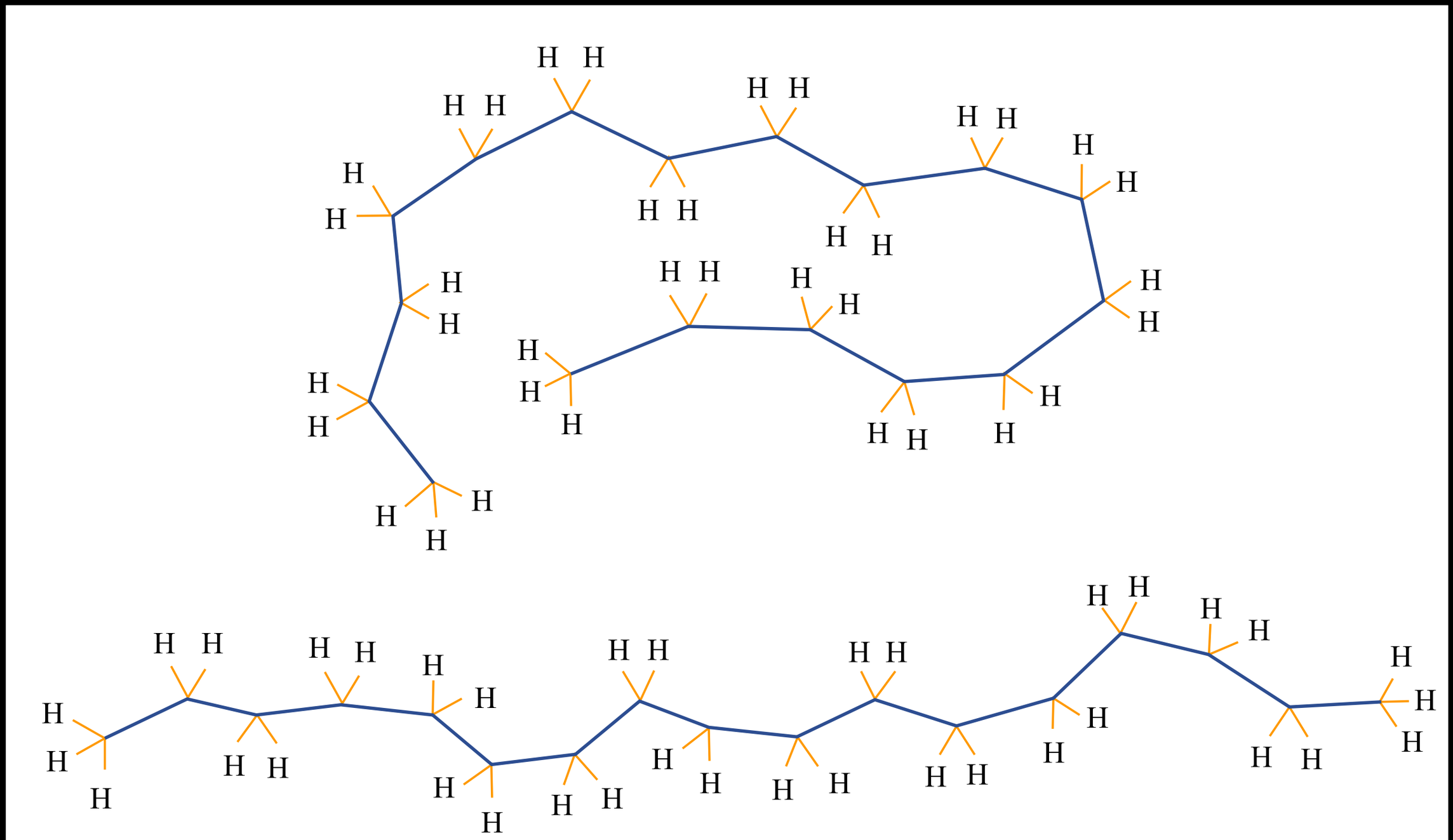




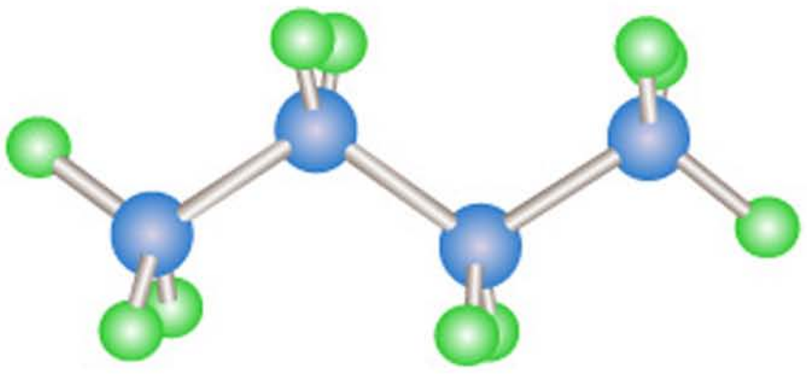
Eclipsed

Image by MIT OpenCourseWare.

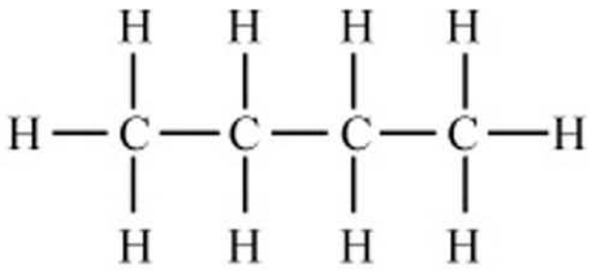
$C_{17}H_{36}$: 2 different conformations, both straight chain



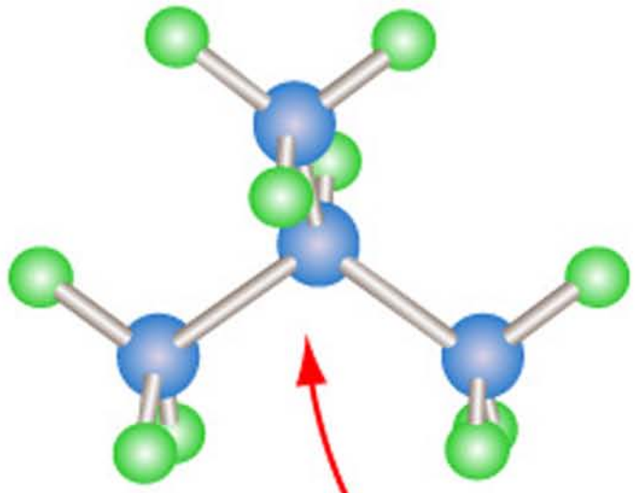
Butane (straight chain)

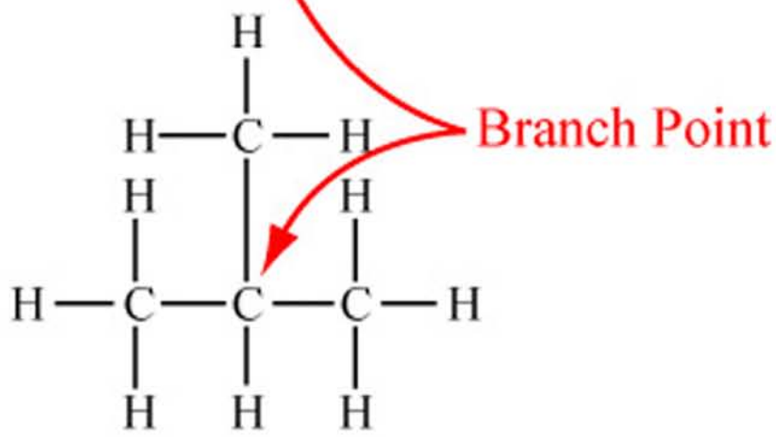


C_4H_{10}



2 - Methylpropane (branched chain)





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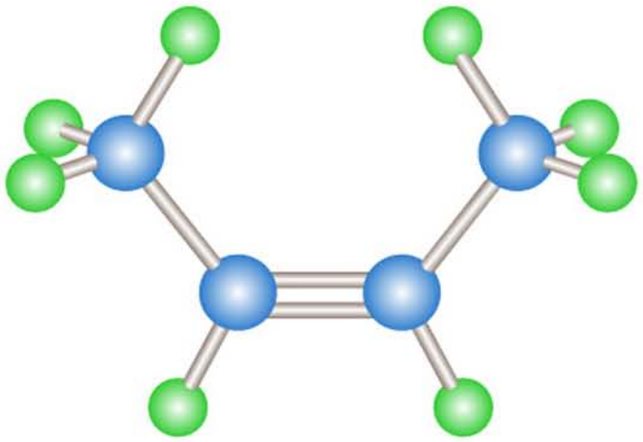
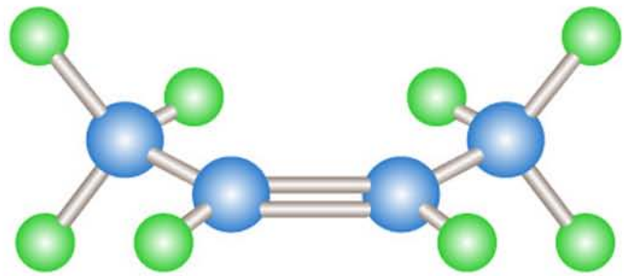
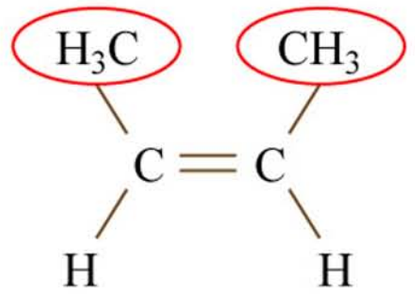


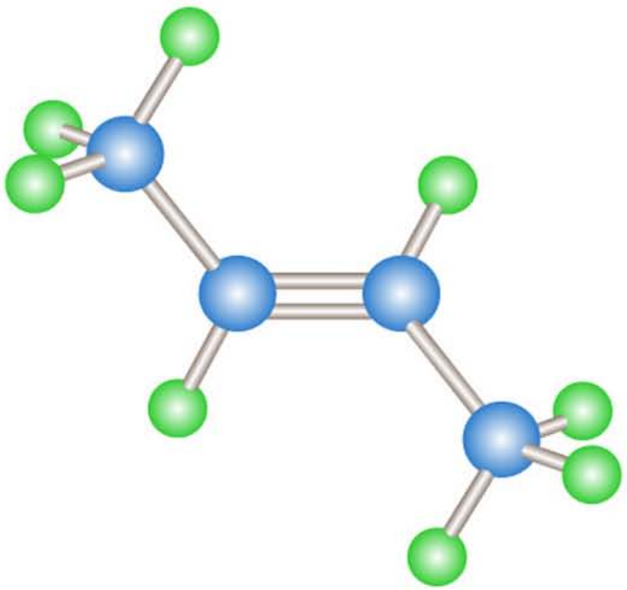
Top View

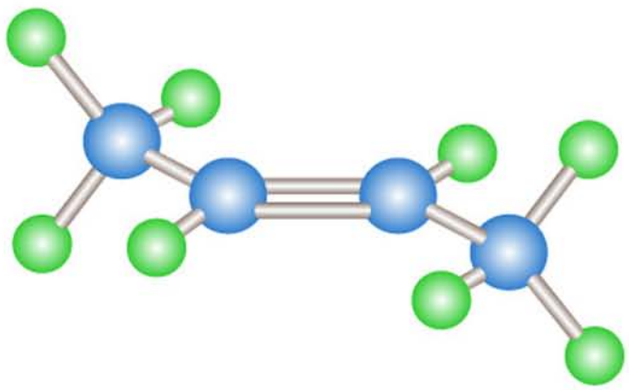


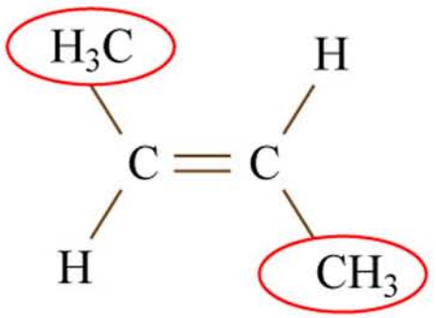
Side View

cis - 2- Butene
(methyl groups on
the same side)





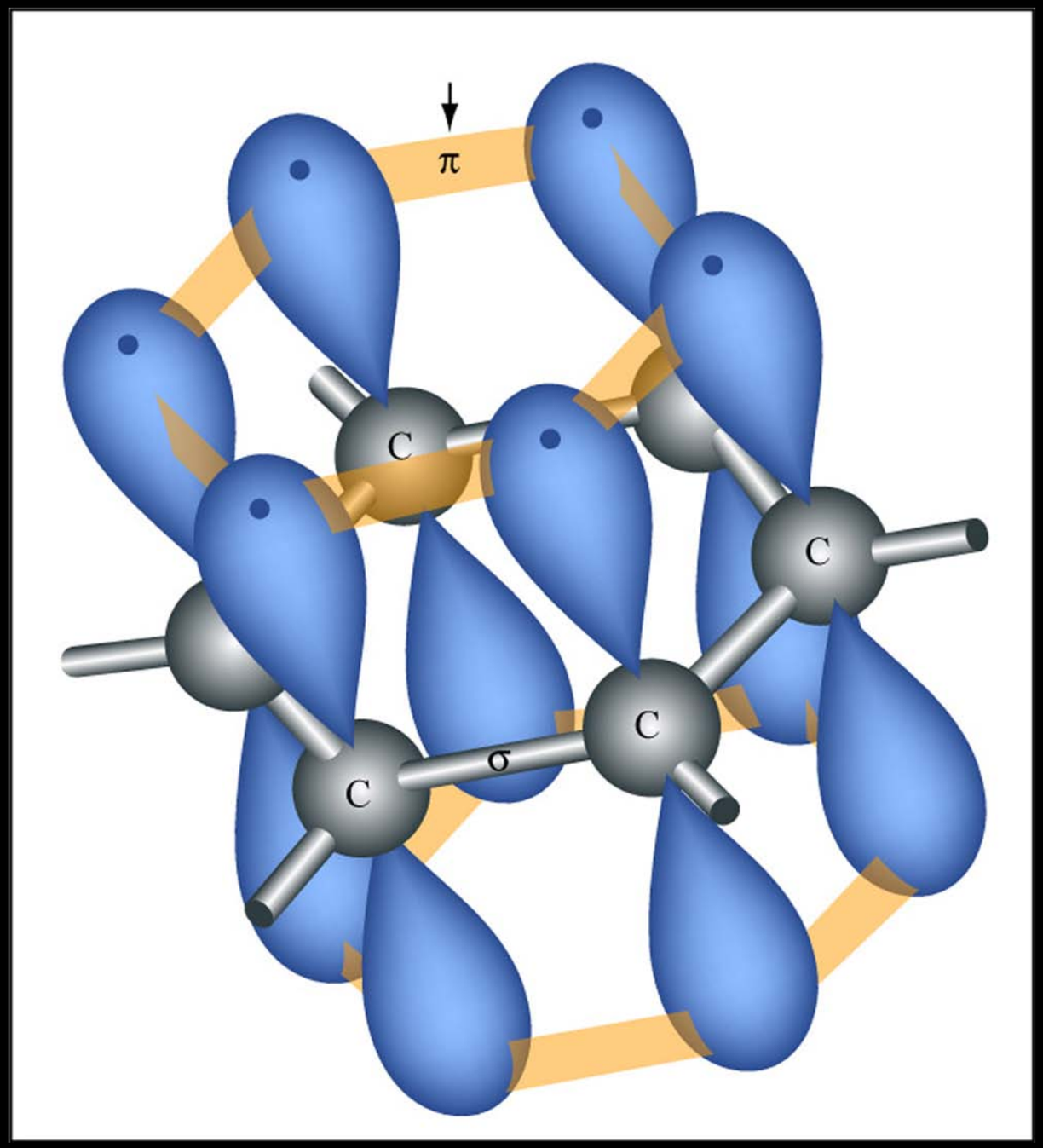




trans - 2- Butene
(methyl groups on
the opposite side)

Isomers of Butene

benzene



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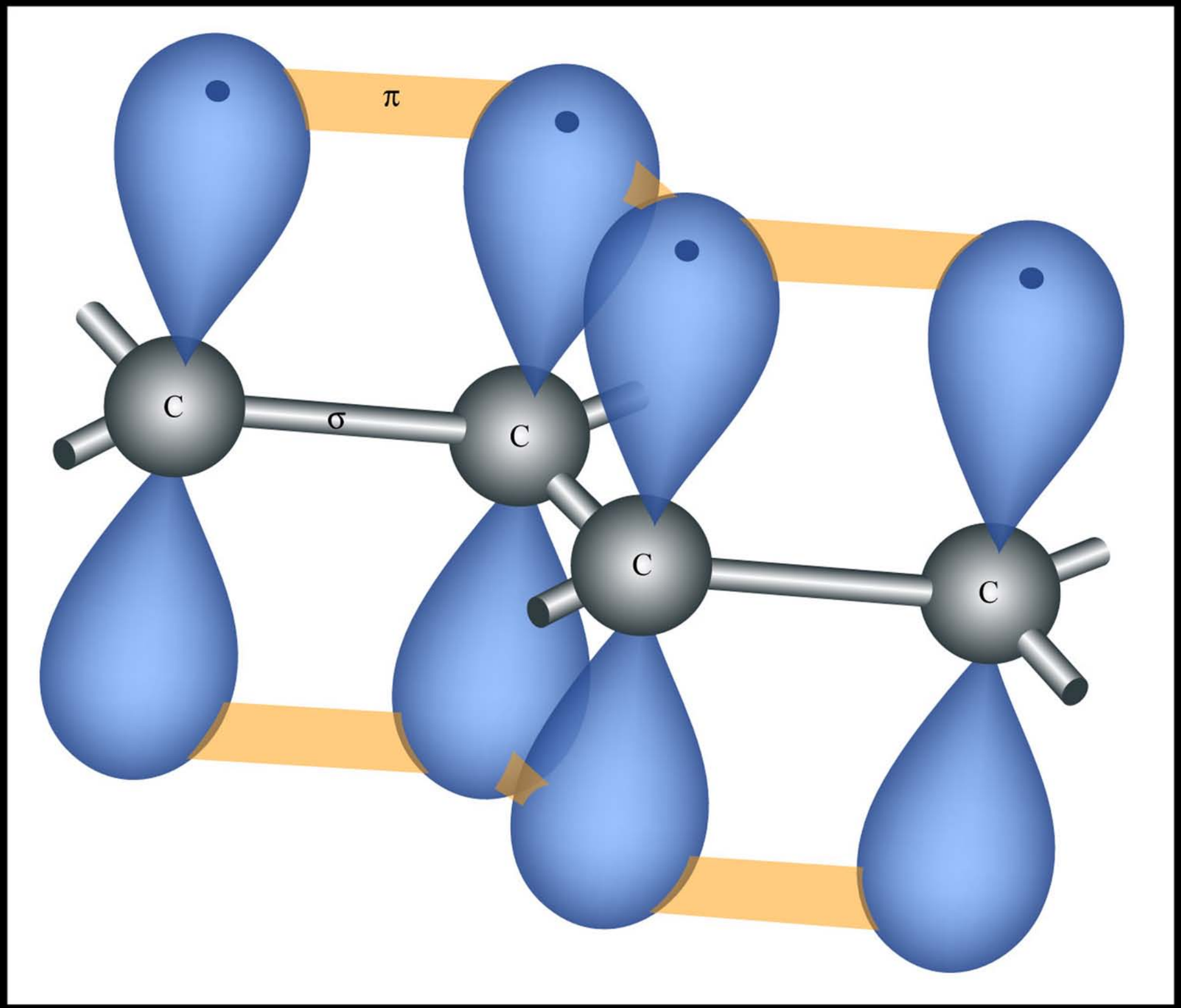
1, 3 butadiene



August Kekulé

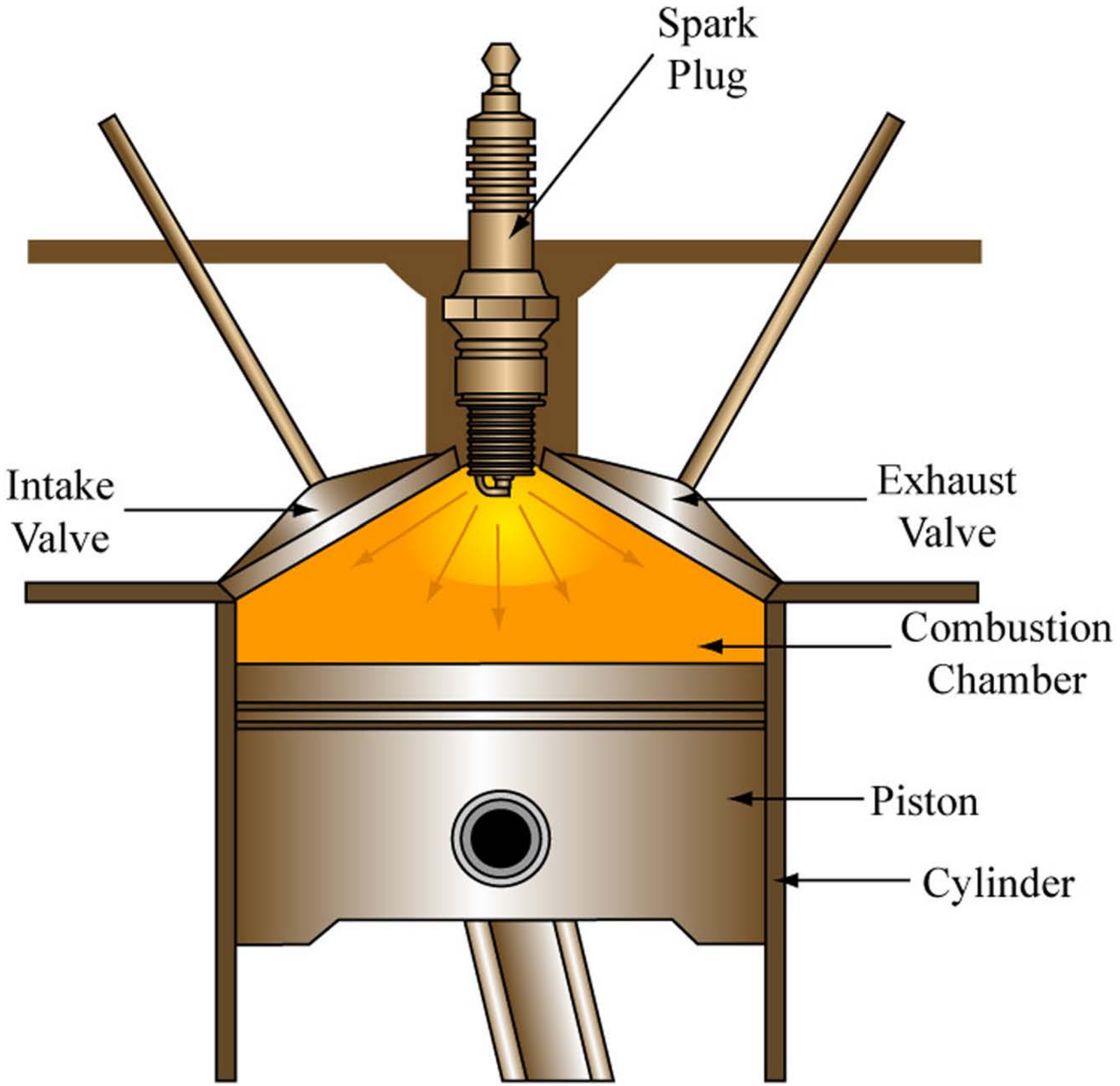
- entered U. Giessen to study Architecture
  but switched to Chemistry
- after Ph.D. took post at St. Bart's Hospital in London
- dozes off on a city bus and dreams of C chains (1855)
- takes post as professor at U. Ghent
- falls asleep by fireplace and dreams of benzene molecule as a snake biting its tail while whirling (1865)
- dubbed the founder of structural chemistry

***K's formula for success*:**

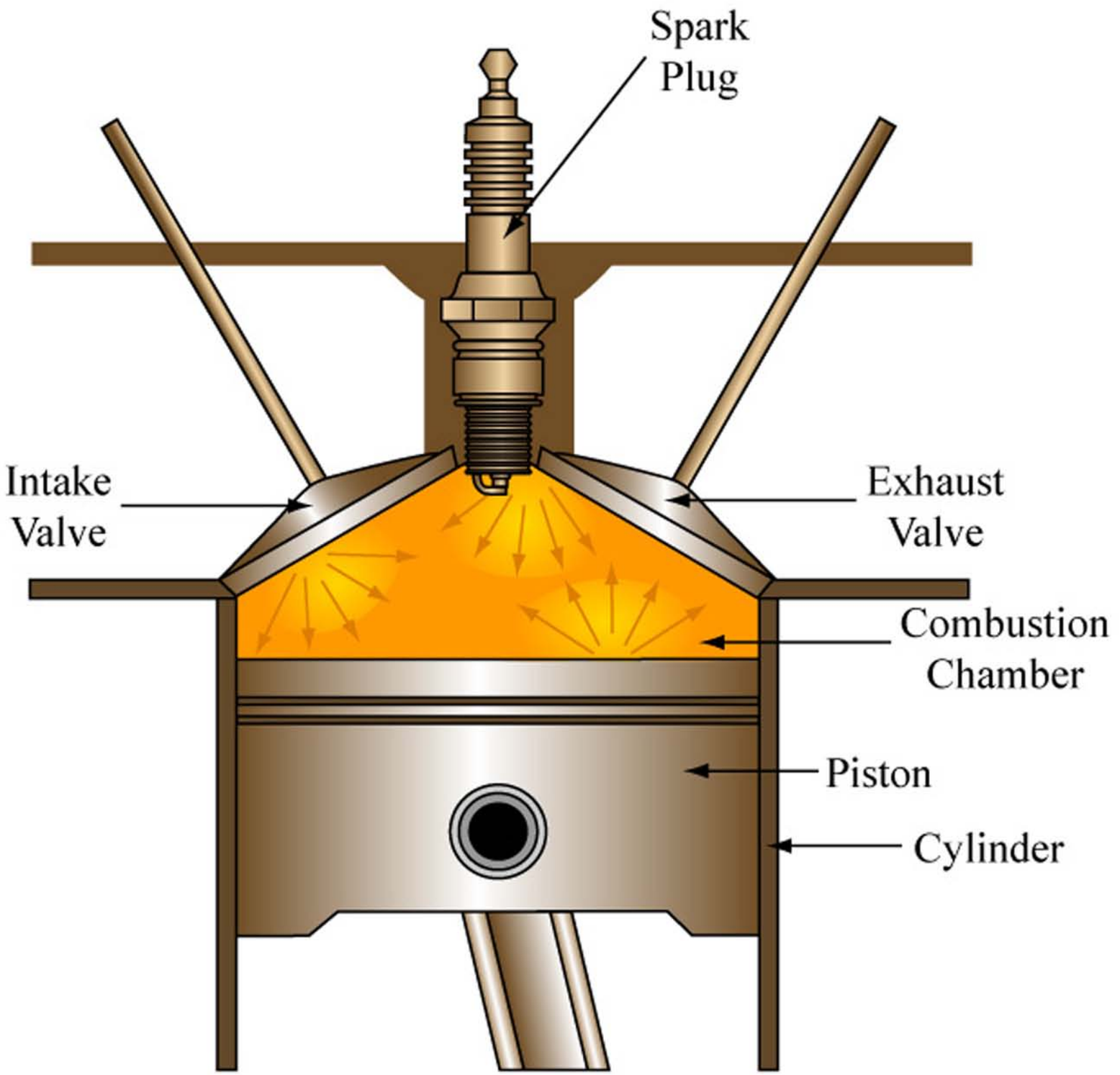
❶ moved into chemistry from another field

❷ dreamer ☞ **GET SOME SLEEP**! "to sleep, perchance to dream"

Normal Combustion



Premature Combustion



gasoline:

- composed of straight-chain alkanes burns unevenly
  - ⇨ "knocking"
- figure of merit: octane number (1927)

100 2,2,4-trimethylpentane (isooctane) ↔ 0 heptane

- test vs. standard solution 90 $^{v}/_{o}$ TMP - 10 $^{v}/_{o}$ heptane
  - ⇨ octane number 90
- additives increase octane rating, e.g., TEL☠ and Et-OH
- remedy by mixing branched-chain and cyclic alkanes made with the aid of catalysts

1964 Avanti
designed by Raymond Loewy
manufactured by Studebaker in South Bend, IN
driven by Donald R. Sadoway

3.091SC Introduction to Solid State Chemistry

Fall 2009