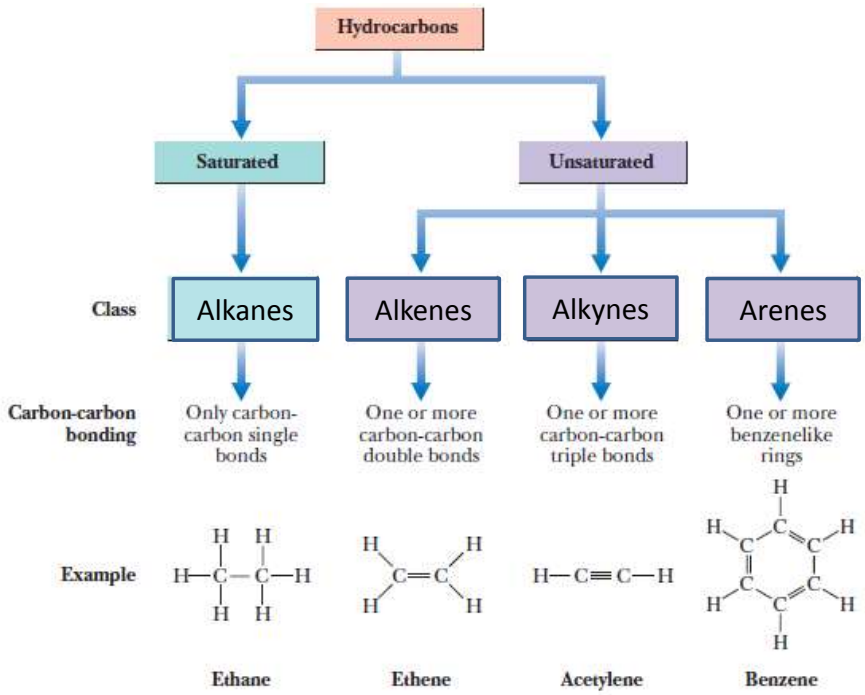
Organic Chemistry

First year

Chemistry students

Lecture 6

Dr Dotsha Jaleel

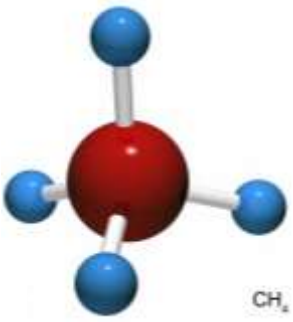


Hydrocarbons

- A **hydrocarbon** is a compound composed of only carbon and hydrogen. There are four types of hydrocarbons based on the characteristics and bonding pattern between the C atoms in each
- An **unsaturated hydrocarbon** is a hydrocarbon that contains one or more carbon-carbon double bonds, triple bonds, or benzene rings

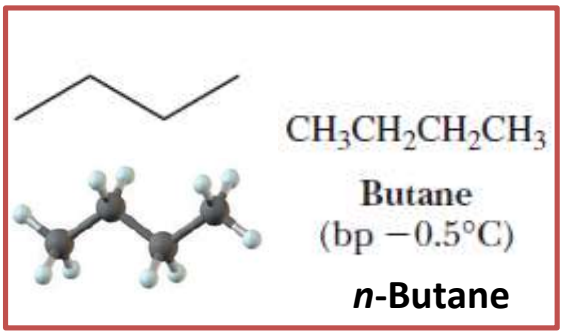
Alkanes

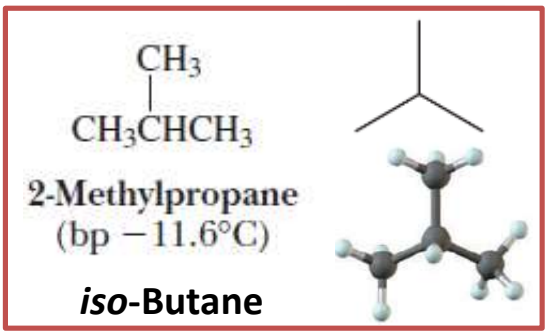
- **Alkanes** are **saturated hydrocarbons** contain only carbon-carbon single bonds. In this context, *saturated* means that each carbon has the maximum number of hydrogen atoms bonded to it.
- Alkanes are represented with the general formula $\mathbf{C_nH_{2n+2}}$
- Alkanes are often referred to as **aliphatic hydrocarbons** because the physical properties of the higher members of this class resemble those of the long carbon-chain molecules we find in animal fats and plant oils (Greek: *aleiphar,* fat or oil).



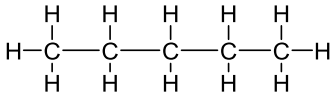
Structural isomerism in alkanes

- **Structural (or constitutional) isomers** are compounds that have the same molecular formula but different structural formulas (differ in the connectivity of their atoms and/or types of bonds they have (single, double, or triple)

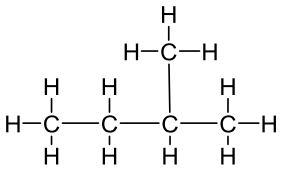




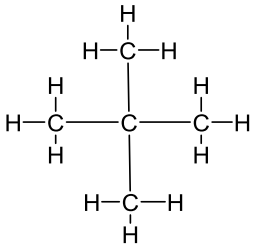
- Isomers of pentane



n-pentane



iso-pentane



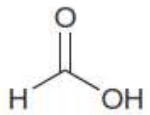
neo-pentane

MOLECULAR FORMULA	NUMBER OF CONSTITUTIONAL ISOMERS
C_3H_8	1
C_4H_{10}	2
C_5H_{12}	3
C_6H_{14}	5
C_7H_{16}	9
C_8H_{18}	18
C_9H_{20}	35
$C_{10}H_{22}$	75
$C_{15}H_{32}$	4,347
$C_{20}H_{42}$	366,319
$C_{30}H_{62}$	4,111,846,763
$C_{40}H_{82}$	62,481,801,147,341

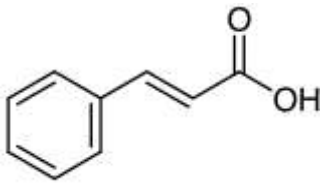
Table showing the number of constitutional isomers for various alkanes

Nomenclature of organic compounds

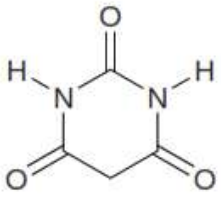
- **Common names**



Formic acid
Isolated from ants and named after the Latin word for ant, *formica*



Cinnamic acid
Obtained from cinnamon



Barbituric acid
Adolf von Baeyer named this compound in honor of a woman named Barbara

- **Systematic (IUPAC) names**
- **Alkane names include two parts**

(1) a prefix that indicates the number of carbon atoms in the chain

(2) the suffix -*ane* to show that the compound is a saturated hydrocarbon.

Hexane

Heptane

* IUPAC: International Union of Pure and Applied Chemistry

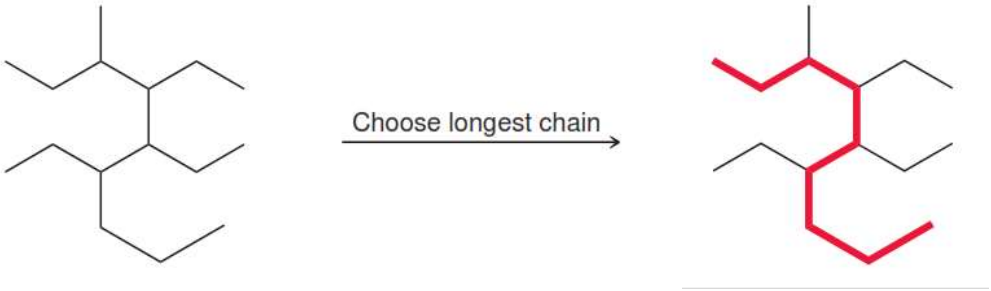
Nomenclature of alkanes

NUMBER OF CARBON ATOMS	PARENT	NAME OF ALKANE	NUMBER OF CARBON ATOMS	PARENT	NAME OF ALKANE
1	*meth*	methane	11	*undec*	undecane
2	*eth*	ethane	12	*dodec*	dodecane
3	*prop*	propane	13	*tridec*	tridecane
4	*but*	butane	14	*tetradec*	tetradecane
5	*pent*	pentane	15	*pentadec*	pentadecane
6	*hex*	hexane	20	*eicos*	eicosane
7	*hept*	heptane	30	*triacont*	triacontane
8	*oct*	octane	40	*tetracont*	tetracontane
9	*non*	nonane	50	*pentacont*	pentacontane
10	*dec*	decane	100	*hect*	hectane

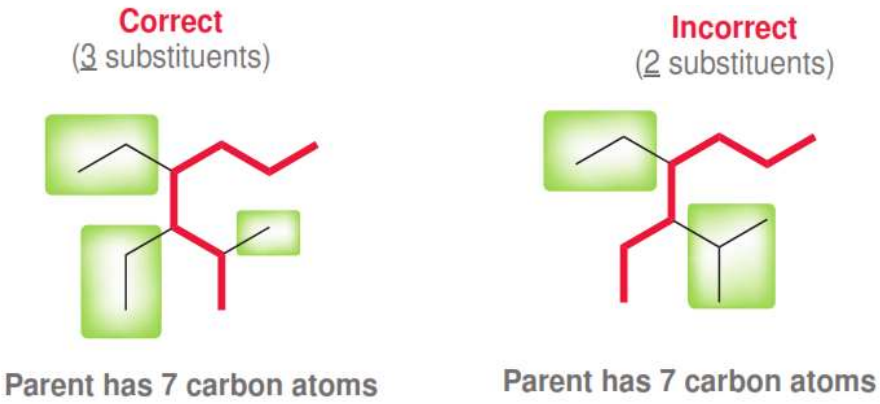
Parent names for alkanes

1. Select the parent chain

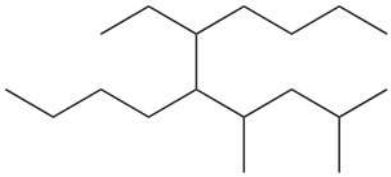
- The first step in naming an alkane is to identify the longest chain, called the parent chain:

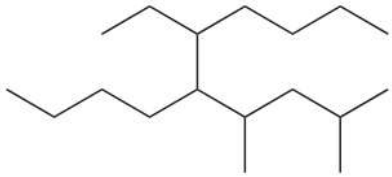


- If there is a competition between two chains of equal length, then choose the chain with the greater number of substituents.
- **Substituents** are the groups connected to the parent chain



- Identify and provide a name for the parent chain in the following compound





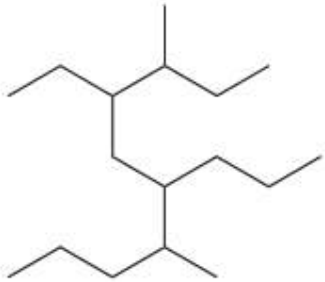
2. Name the substituents

- Substituents are named using the same terminology used for the parents by adding the letters "**yl**"
- These groups are generally called **alkyl groups**

NUMBER OF CARBON ATOMS IN SUBSTITUENT	TERMINOLOGY
1	*Methyl*
2	*Ethyl*
3	*Propyl*
4	*Butyl*
5	*Pentyl*
6	*Hexyl*
7	*Heptyl*
8	*Octyl*
9	*Nonyl*
10	*Decyl*

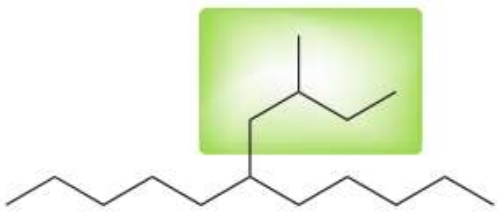
Names of alkyl groups

- Identify and name all the substituents in the following compound

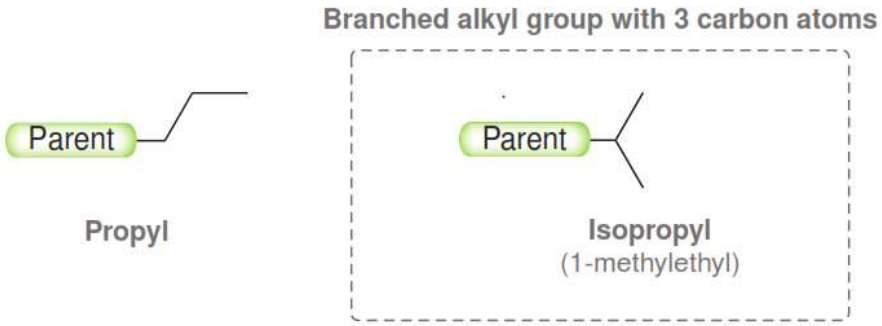


Naming branched (complex) substituents

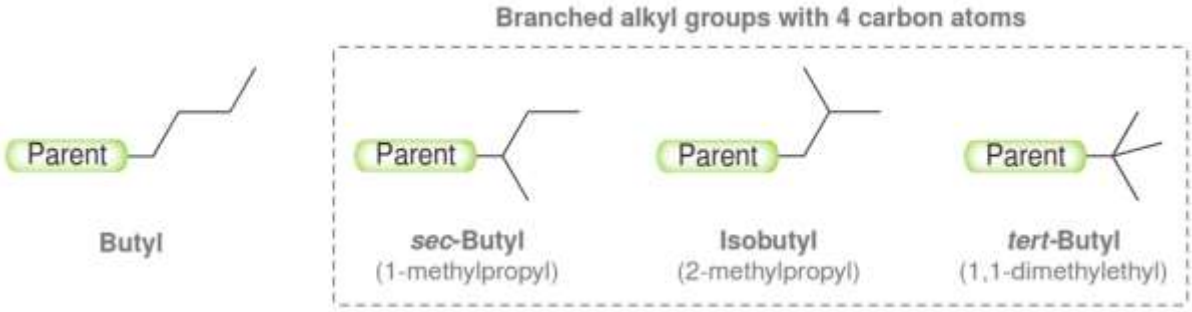
- Start numbering the substituent, going ***away*** from the parent chain
- Number the longest straight chain alkyl group
- If numbers were required in naming a complex substituent, place parentheses around the name of the substituent to avoid confusion with the numbers on the main parent chain



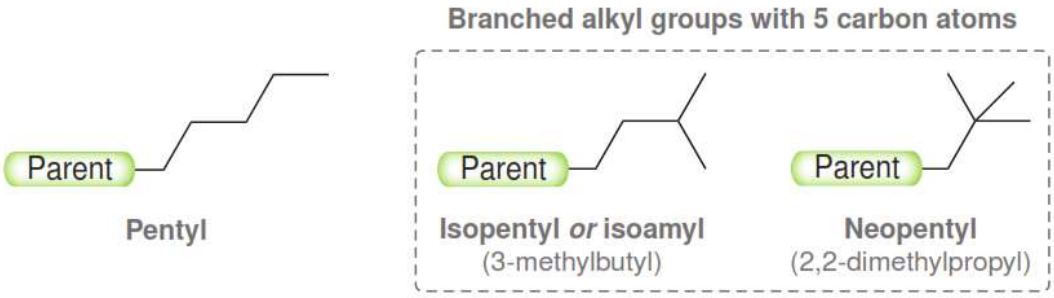
- Some complex substituent have common names



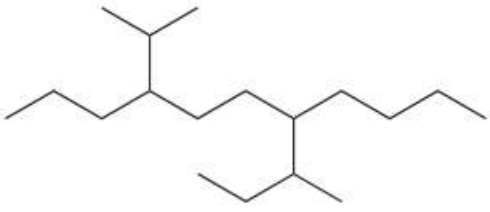
- Alkyl groups with four carbon atoms can be branched in three different ways:



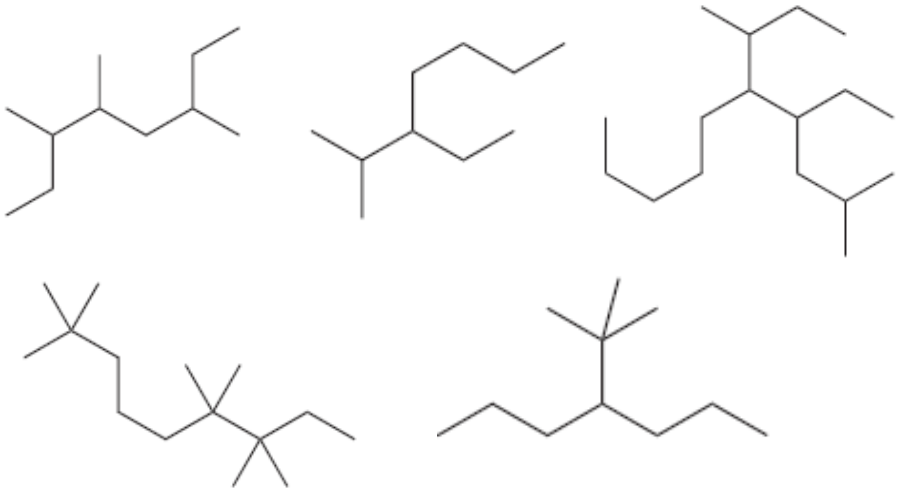
- Alkyl groups bearing five carbon atoms can be branched in many more ways. Here are two common ways:



- In the following compound, identify the substituents, and indicate their systematic name

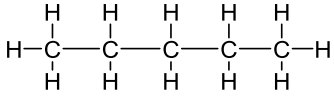


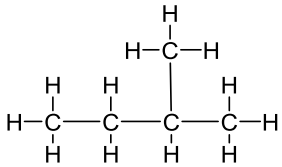
- Provide a systematic name for each of the following compounds

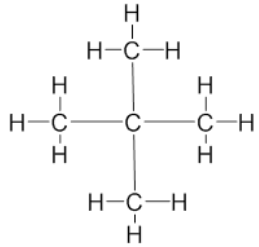


Types of carbon and hydrogen atoms

- A primary (1^o) carbon atom is attached to only one other carbon atom;
- A secondary (2^o) is attached to two others;
- A tertiary (3^o) to three others.
- Hydrogen atoms are similarly classified, being given the same designation (1^o, 2^o or 3^o) as the carbon atom to which they are attached.







Physical properties of alkanes

- What is the effect of M.wt. on melting and boiling points?
- What is the effect of branching on melting and boiling points?

Industrial sources

- Methane is obtained from anaerobic decay of plants
- Natural gas consists chiefly of methane and smaller amounts of ethane, propane, and higher alkanes.
- Most of it is consumed as fuel without purification.

- The propane-butane fraction is separated from the more volatile components by liquefaction, compressed into cylinders, and sold as bottled gas
- Petroleum is separated by distillation into the various fractions

Fraction	Temperature, °C	Carbon Number
Gas	Below 20°	C_1–C_4
Petroleum ether	20–60°	C_5–C_6
Ligroin (light naphtha)	60–100°	C_6–C_7
Natural gasoline	40–205°	C_5–C_{10}, and cycloalkanes
Kerosene	175–325°	C_{12}–C_{18}, and aromatics
Gas oil	Above 275°	C_{12} and higher
Lubricating oil	Non-volatile liquids	Probably long chains attached to cyclic structures
Asphalt or petroleum coke	Non-volatile solids	Polycyclic structures