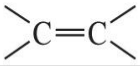
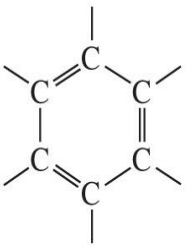
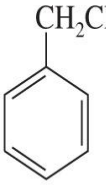
Hydrocarbons

Hydrocarbon: Compound composed of only carbon and hydrogen

Saturated Hydrocarbons: Compound with only single bonds

Unsaturated Hydrocarbons: Compounds with at least one double or triple bond.

TABLE 3-1 Hydrocarbon Classifications

Compound Type	Functional Group	Example
alkanes	none (no double or triple bonds)	$CH_3—CH_2—CH_3$, propane
alkenes	 double bond	$CH_2=CH—CH_3$, propene
alkynes	$—C\equiv C—$ triple bond	$H—C\equiv C—CH_3$, propyne
aromatics	benzene ring 	 ethylbenzene

Alkanes

Alkanes are organic compounds that consist entirely of single-bonded carbon and hydrogen atoms and lack any other functional groups. Alkanes have the general formula C_nH_{2n+2} and can be subdivided into the following three groups: the linear straight-chain

alkanes, branched alkanes, and cycloalkanes. Alkanes are also *saturated hydrocarbons*

Physical Properties of Alkanes:

- Alkanes are colourless.
- Alkanes are less dense than water (alkanes float on top of water).
- Alkanes are non-polar molecules so they are more soluble in non-polar solvents than they are in polar solvents. Alkanes are insoluble in water.
- The melting and boiling points of the shorter chain alkanes is low, but the melting and boiling of alkanes increase as the number of carbon atoms in the carbon chain increases.

Name	Molecular Formula	Molar Mass ($g\ mol^{-1}$)	Melting Point (°C)	Boiling Point (°C)	State (25°C, 101.3kPa)	Density of liquid ($g\ cm^{-3}$, 20°C)	Flashpoint (°C)	Enthalpy of Combustion ($kJ\ mol^{-1}$)	Uses
methane	CH_4	16	-182	-162	gas			-889	*major component of natural gas (fuel)*
ethane	C_2H_6	30	-183	-88.6	gas			-1560	*component of natural gas (fuel)*
propane	C_3H_8	44	-188	-42.1	gas			-2217	*component of liquefied petroleum gas (LPG), bottled gas (fuel)*
butane	C_4H_{10}	58	-138	-0.5	gas			-2874	*component of liquefied petroleum gas (LPG), cigarette lighters (fuel)*
pentane	C_5H_{12}	72	-130	36.1	liquid	0.626	-49	-3536	*component of petrol (gasoline, fuel)*
hexane	C_6H_{14}	86	-95.3	68.7	liquid	0.659	-22	-4190	*component of petrol (gasoline, fuel)*
heptane	C_7H_{16}	100	-90.6	98.4	liquid	0.68	-4	-4847	*component of petrol (gasoline, fuel)*
octane	C_8H_{18}	114	-56.8	126	liquid	0.703	13	-5506	*major component of petrol (gasoline, fuel)*
nonane	C_9H_{20}	128	-50	151	liquid	0.72	31		*component of petrol (gasoline, fuel)*
decane	$C_{10}H_{22}$	142	-30	174	liquid	0.730	46		*component of petrol (gasoline, fuel)*

IUPAC Rules

- ♣ Rule 1:Find the longest continuous chain of carbon atoms, and use the name of this chain as the base name of the compound.
- ♣ Rule 2:Number the longest chain, beginning with the end of the chain nearest a substituent.
- ♣ Rule 3:Name the groups attached to the longest chain as alkyl groups. Give the location of each alkyl group by the number of the main-chain carbon atom to which it is attached.
- ♣ Write the alkyl groups in alphabetical order regardless of their position on the chain.

Sub-rules for IUPAC nomenclature

1. If there are two or more longest chains of equal length:

- Choose the one having the largest number of substituents.
- Choose the one having the simples substituents.

2. If both ends of the root chain have equidistant substituents.

- Begin numbering at the end nearest a third substituent, if one is present.
- Begin numbering at the end nearest the first cited group

Common Alkyl Groups

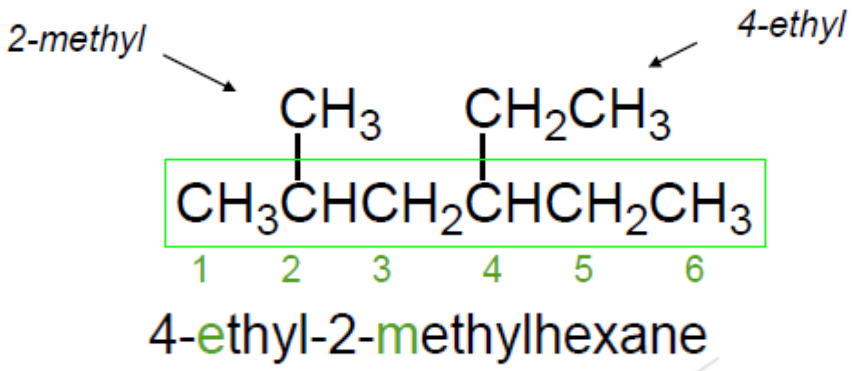
Parent alkane	Parent structure	Alkyl group structure	Alkyl group name
methane	CH_4	$--CH_3$	methyl
ethane	CH_3CH_3	$--CH_2CH_3$	ethyl
propane	$CH_3CH_2CH_3$	$--CH_2CH_2CH_3$ | CH_3CHCH_3	propyl isopropyl
n-butane	$CH_3CH_2CH_2CH_3$	$--CH_2CH_2CH_2CH_3$ | $CH_3CHCH_2CH_3$	butyl sec-butyl
isobutene	CH_3 | CH_3CHCH_3	CH_3 | $--CH_2CHCH_3$ CH_3 | CH_3CCH_3 |	Isobutyl t-butyl

Common Nonalkyl Groups

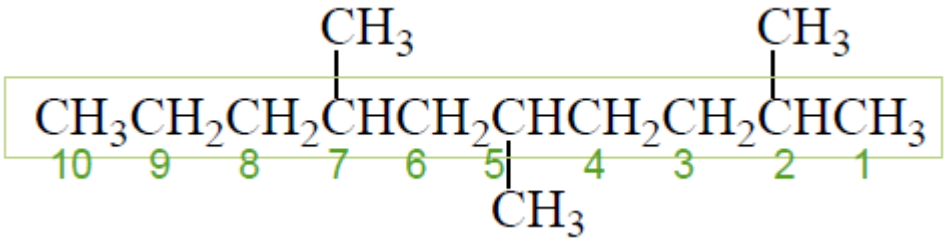
Table 11.6 Common Nonalkyl Groups

Group	Name
—F	fluoro
—Cl	chloro
—Br	bromo
—I	iodo
—NO_2	nitro
—NH_2	amino

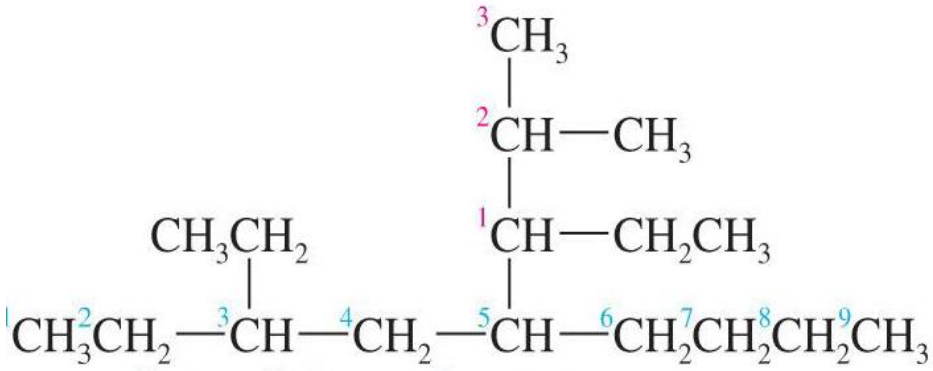
For example :



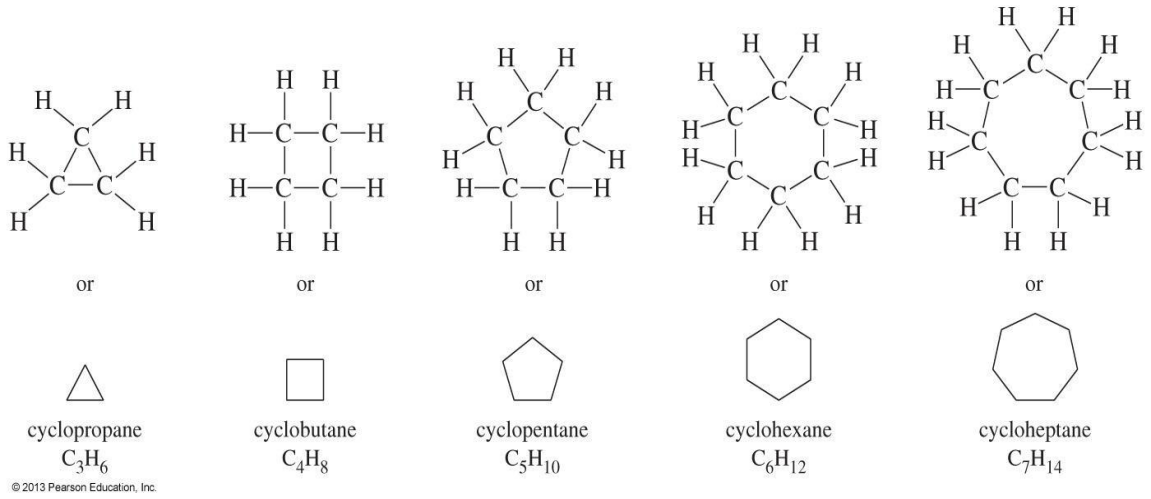
4-ethyl-2-methylhexane



2,5,7-trimethyldecane

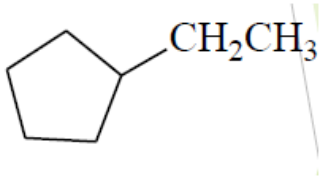


Cycloalkanes: C_nH_{2n}



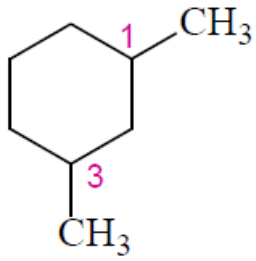
Cycloalkane Nomenclature

- Cycloalkane is the main chain: alkyl groups attached to the cycloalkane will be named as alkyl groups.
- If only one alkyl group is present, then no number is necessary

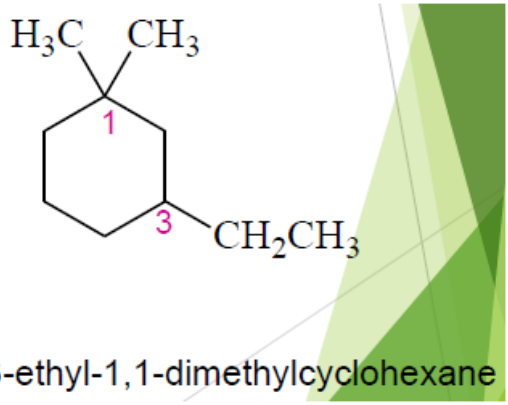


Ethylcyclopentane

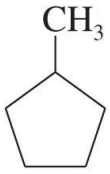
- If there are two or more substituents, number the main chain to give all substituents the lowest possible number.



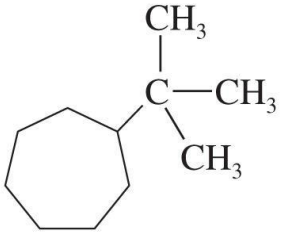
1,3-dimethylcyclohexane



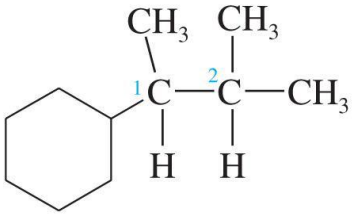
3-ethyl-1,1-dimethylcyclohexane



methylcyclopentane



tert-butylcycloheptane



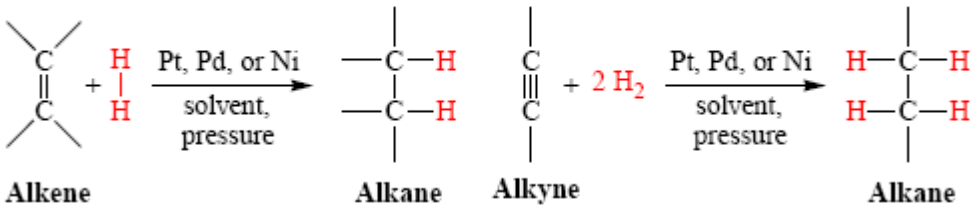
(1,2-dimethylpropyl)cyclohexane

Preparation of Alkanes

1. From Unsaturated Hydrocarbons (hydrogenation)

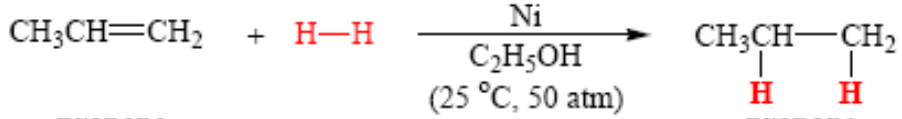
Unsaturated hydrocarbons (alkenes and alkynes) react with H_2 in the presence of finely divided catalysts such as platinum, palladium or nickel to form alkanes. This process is called hydrogenation.

General Reaction

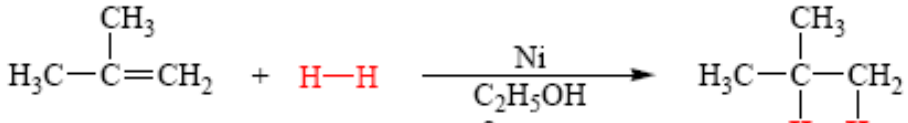


Alkene — Alkane — Alkyne — Alkane

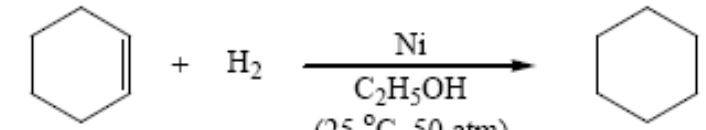
Specific Examples



propene — propane



2-Methylpropene — Isobutane

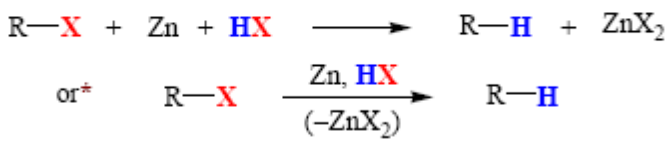


Cyclohexene — Cyclohexane

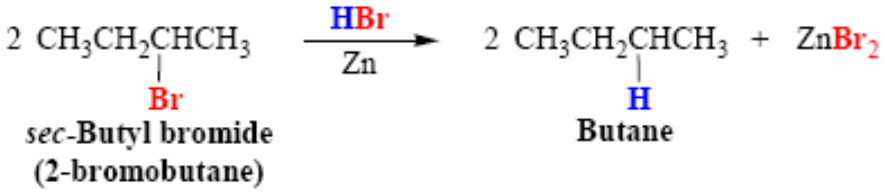
2. From alkyl Halides

A. Reduction of alkyl halides

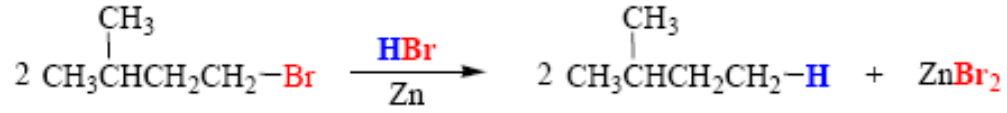
General Reaction



Specific Examples



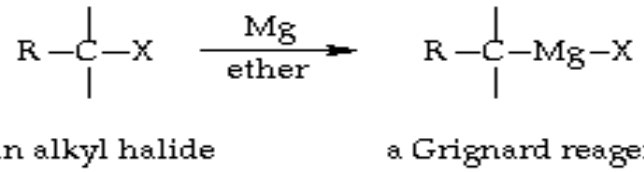
sec-Butyl bromide (2-bromobutane) → **Butane**



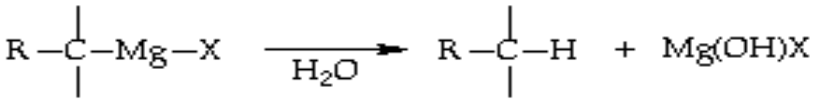
Isopentyl bromide (1-bromo-3-methylbutane) → **Isopentane (2-methylbutane)**

B. Hydrolysis of Grignard Reagent

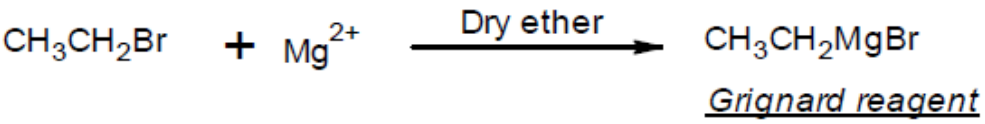
- Grignard reagent is an alkyl magnesium halide compound, R-Mg-X
- The Grignard reagent is formed when a solution of an Alkyl Halide (R-X) is allowed to stand over a metallic magnesium in the presence of dry ether .
- Then Grignard reagent react with water or alcohol to form alkane.



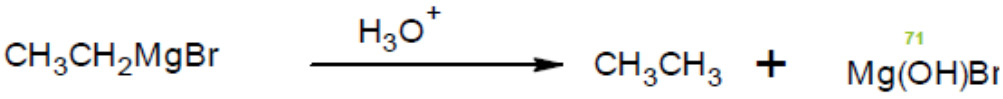
an alkyl halide a Grignard reagent



alkane



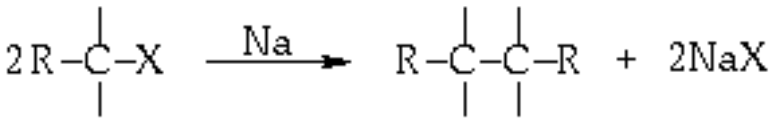
Grignard reagent



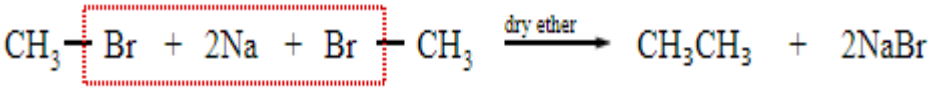
C. Wurtz Reaction

This is the reaction of two alkyl halides (R-X) with metallic sodium to give symmetrical alkanes.

The wurtz reaction is a poor method for the preparation of unsymmetrical alkanes.



a symmetrical alkane

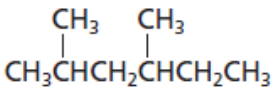


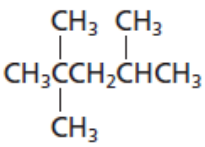
Problem

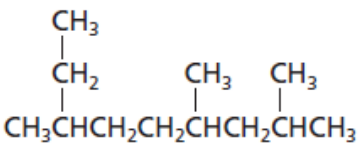
Give the structures of 4-isopropyloctane , 5-*t*-butyldecane and

a. 2,3-dimethyl-5-propyldecane
b. 3,4,5-triethyloctane

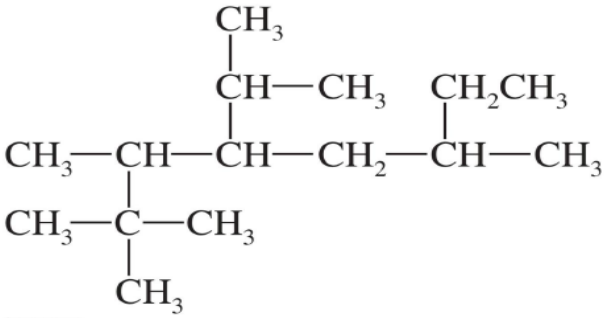
Use the IUPAC rules to name the following structures.

a. 

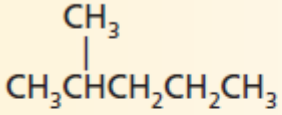
b. 

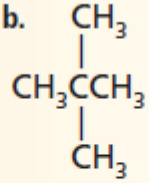
c. 

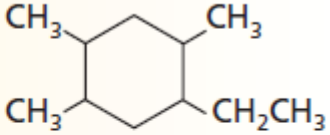
Give a systematic (IUPAC) name for the following compound.



13. Name the following structures using IUPAC rules.

a. 

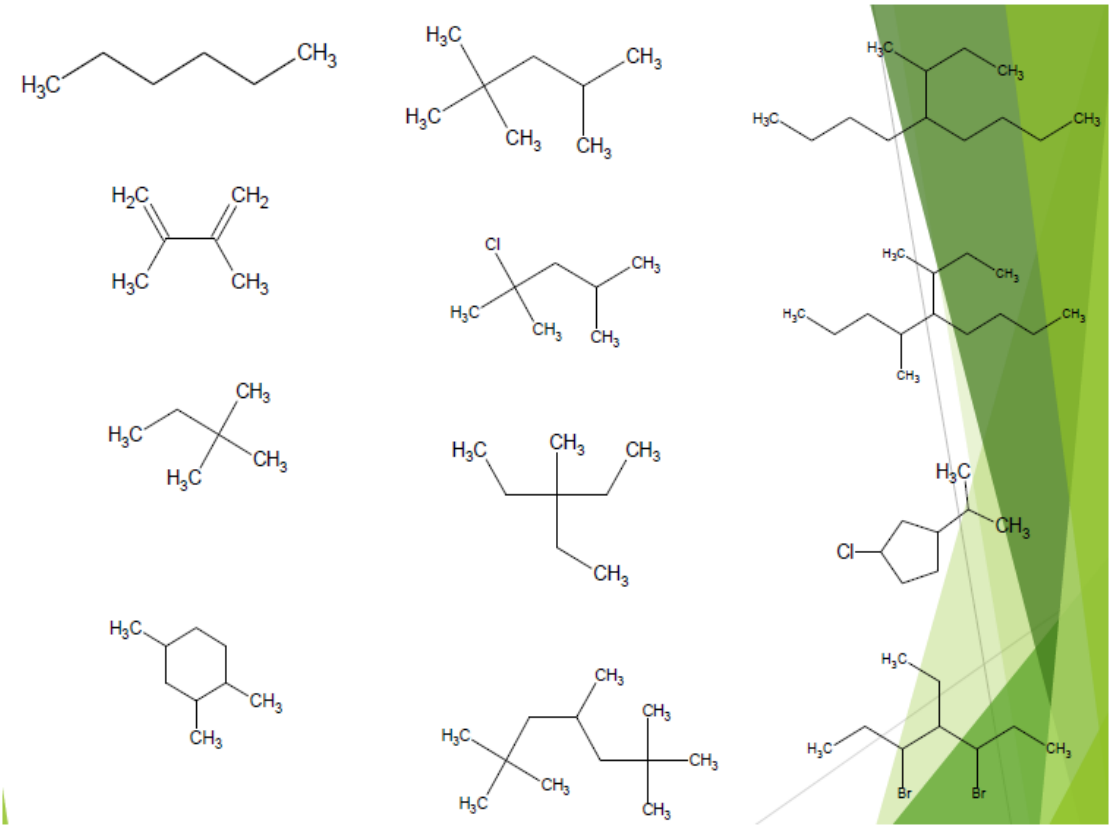
b. 

c. 

14. Describe the general properties of alkanes.

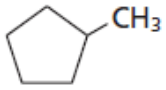
15. Draw the molecular structure for each of the following.

a. 3, 4-diethylheptane
b. 4-isopropyl-3-methyldecane
c. 1-ethyl-4-methylcyclohexane
d. 1,2-dimethylcyclopropane

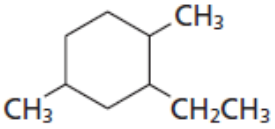


Use IUPAC rules to name the following structures.

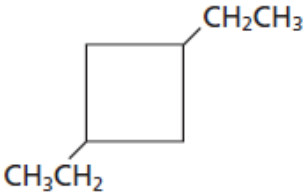
a.



b.



c.



Challenge Draw the structures of the following cycloalkanes.

a. 1-ethyl-3-propylcyclopentane

b. 1,2,2,4-tetramethylcyclohexane