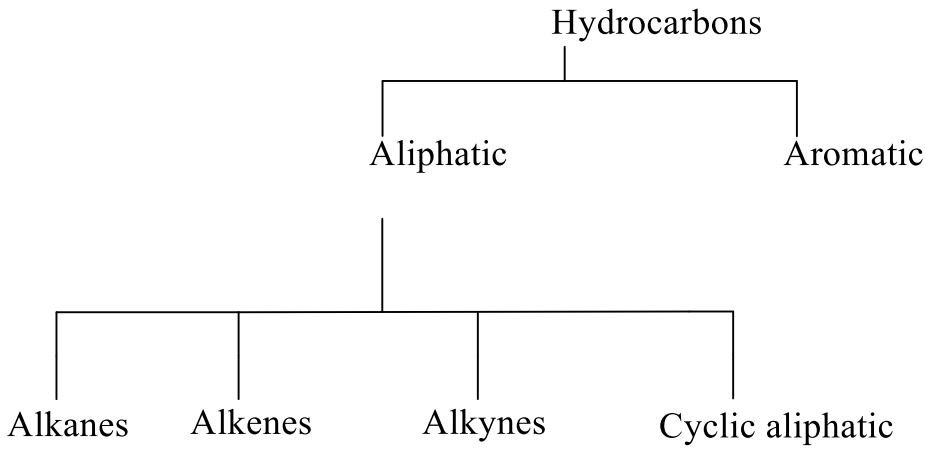
Hydrocarbons

Organic compounds contain only two elements ,hydrogen and carbon and hence are known as Hydrocarbons.
On the basis of structure Hydrocarbons are divided into two main classes aliphatic and aromatic . Aliphatic hydrocarbons are divided into families (alkanes ,alkenes ,alkyne and cyloalkane) . We shall take up these families in the order given .



Physical properties of alkanes

Physical properties of alkanes constants for a number of the n- alkanes. As we can see the boiling points and melting points, rise the number of carbons increases .the process of boiling and melting point require overcoming the intermolecular forces of a liquid and a solid ; the boiling points and melting points, rise because these intermolecular forces increases as increases molecules get larger .Except for the very small alkanes the boiling point rise 20- 30^{o}C degrees for each carbon that is added to the chain ;the first four n-alkanes are gases .but ,as of the rise a result in boiling point and melting point with increasing chain length, the next (C_5-C_{17})are liquids .and those containing 18 carbon or more are solid

In agreement with the rule of thumb (Like dissolves like) the alkane soluble in non- polar solvents such as benzene ,ether ,chloroform and are insoluble in water and other highly polar solvents .

The density increase with size of the alkanes ,but, tend to level off about 0.8 thus all alkanes are less dense than water .in general ,to be denser than water a compound must contain heavy atom like bromine ,iodide ,or several atoms like chlorine .

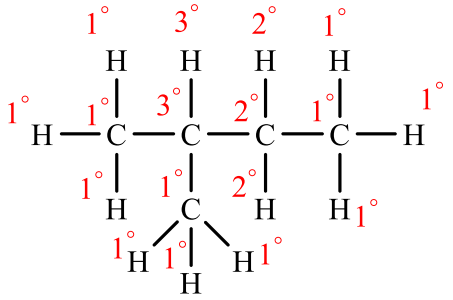
Classes of carbon atoms and hydrogen atoms

Primary (1^{o}): carbon atoms is attached to only one other carbon atoms

Secondary (2^{o}): carbon atoms is attached to two others carbon atoms

Tertiary(3^{o}) : carbon atoms is attached to three others carbon atoms

Each hydrogen atom is similarly classified being given the same designation of primary ,secondary , or tertiary as the carbon atom to which it is attached .



The Structural of Alkanes

Table : Names and formulas of the first ten unbranched alkanes

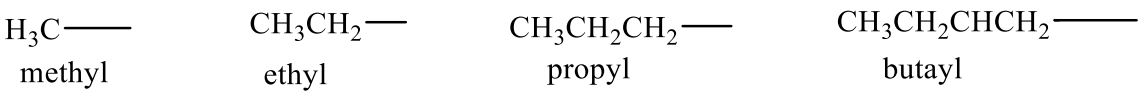
Name	Number of carbon	Molecular formula	Structural formula	Number of Structural Isomers
methane	1	CH_4	CH_4	1
ethane	2	C_2H_6	CH_3CH_3	1
propane	3	C_3H_8	$CH_3CH_2CH_3$	1
butane	4	C_4H_{10}	$CH_3CH_2CH_2CH_3$	2
pentane	5	C_5H_{12}	$CH_3(CH_2)_3CH_3$	3
hexane	6	C_6H_{14}	$CH_3(CH_2)_4CH_3$	5
heptane	7	C_7H_{16}	$CH_3(CH_2)_5CH_3$	9
octane	8	C_8H_{18}	$CH_3(CH_2)_6CH_3$	18
nonane	9	C_9H_{20}	$CH_3(CH_2)_7CH_3$	35
decane	10	$C_{10}H_{22}$	$CH_3(CH_2)_8CH_3$	75

Alkyl group : -

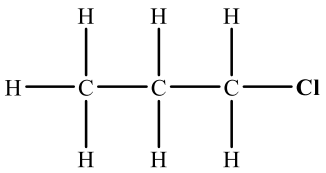
If a hydrogen atom is removed from an alkane the remain is called an alkyl group with general formula C_nH_{2n+1}

we have seen that chloroform CH_3Cl is also known as methyl chloride . the CH_3 group is called methyl wherever it appears. CH_3Br being methyl bromide , CH_3I methyl Iodide, CH_3OH methyl alcohol .in the same way ,the C_2H_5 group is called Ethyl , C_3H_7 propyl ,C_4H_9 butyl ;and so on .

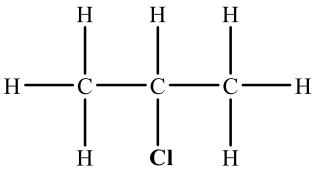
These groups are named simply by dropping (**ane**) from the name of the corresponding alkane and replacing it by **(–yl-).** They are known collectively as alkyl groups. the general formula for an alkyl group is C_nH_{2n+1}, it contain one less hydrogen than the parent alkane C_nH_{2n+2} .



The propane chain, but differ in the point of attachment of the chlorine ; they are called **n-propyl** and **isopropyl**. We can distinguish the two chlorides by the names



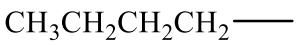
n-propyl chloride



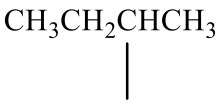
isopropyl chloride

n-propyl chloride and isopropyl chloride ; we distinguish the two propyl bromides, iodides, alcohols , and so on in the same way.

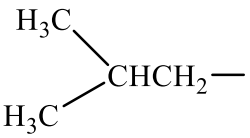
We find that there are four butyl groups, two derived from the straight – chain n-butane , and two derived from the branched-chain isobutene. These are given the designations ***n***-(normal), ***sec*** (secondary), ***iso***-, and ***tert***-(tertiary), as shown below. Again the difference between n-butyl and sec-butyl and between isobutyl and tert-butyl lies in the point of attachment of the alkyl group to the rest of the molecule.



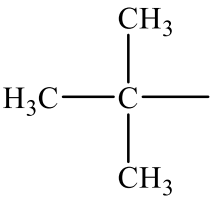
n-butyl



sec-butyl



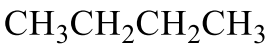
isobutyl



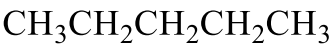
tert-butyl

Common name of alkanes

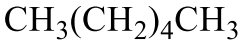
As we have seen the prefix n-,iso and neo are adequate to differentiate the various butanes and pentanes , the prefix (n-) has been retained for any alkane, in which all carbons from a continuous chain with no branching :



n-butane

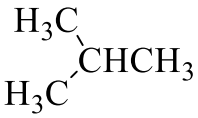


n-pentane

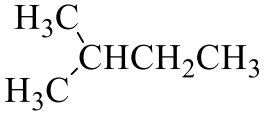


n-hexane

An ***iso alkane*** is a compound (of six carbons or less) in which all carbons except one from a continuous chain and that one carbon is attached to the next –to- end carbon:

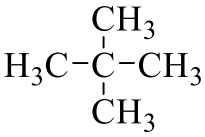


isobutane

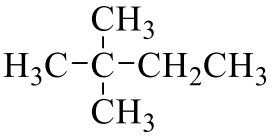


isopentane

isohexane



neopentane

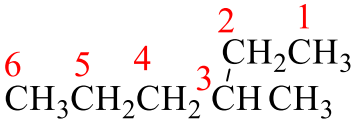


neohexane

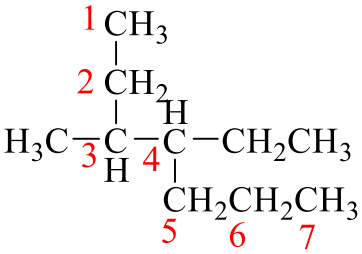
IUPAC name of alkanes

IUPAC (international union of pure and applied chemistry)

1- **(a)**Choose the longest continuous chain of carbon atoms in the molecule , and use the name of that chain as the parent name.

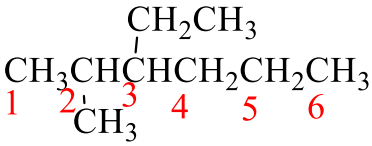


Named as asubsituted hexane



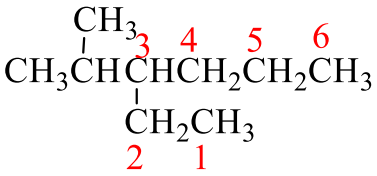
Named as asubsituted heptane

(b) If two different chain of equal length are present, choose the one with the larger number of branch point as the present.



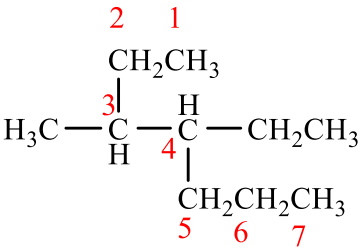
Named as a hexane with **two substituents**

NOT



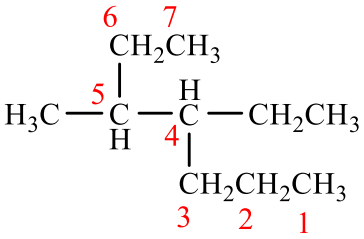
Named as a hexane with **one substituents**

2- In numbering the parent carbon chain , start at whichever end result s in the use of the lowest numbers .



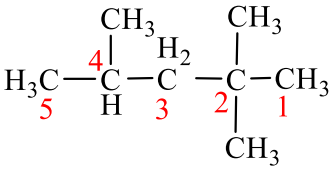
4-ethyl-3-methylheptane

NOT

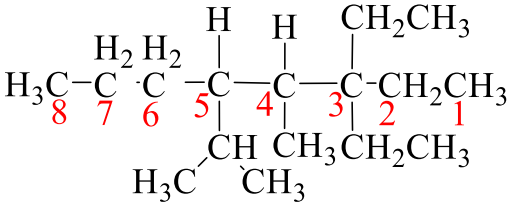


4-ethyl-5-methylheptane

3- If the same alkyl group occurs more than once as a side chain. indicate this by the prefix di , tri ,tetra .....etc....to show how many of these alkyl group there are and indicate by various numbers the positions of each group .as 2,2,4-trimethylpentane .



4- If there are several difference alkyl groups attached to the parent chain name them in order of increasing size or in alphabetical order ; as in 3,3-di ethyl -5-iso propyl 4-methyl octane .



3,3-diethyl-5-isopropyl-4-methyloctane

Reaction of alkanes

1- Combustion of alkanes

The reaction of alkanes with oxygen to formed carbon dioxide + water and most important of all heat ,is the chief reaction occurring in the internal combustion engine ;
For example

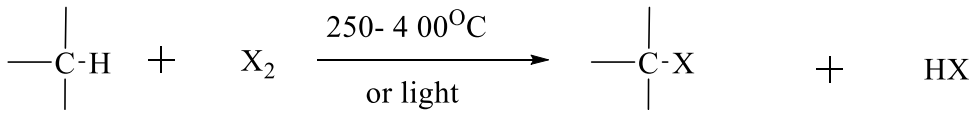
$$C_nH_{2n+2} + O_2 \longrightarrow n\,CO_2 + (n+1)\,H_2O$$

$$C_3H_8 + 5O_2 \longrightarrow 3CO_2 + 4\,H_2O$$

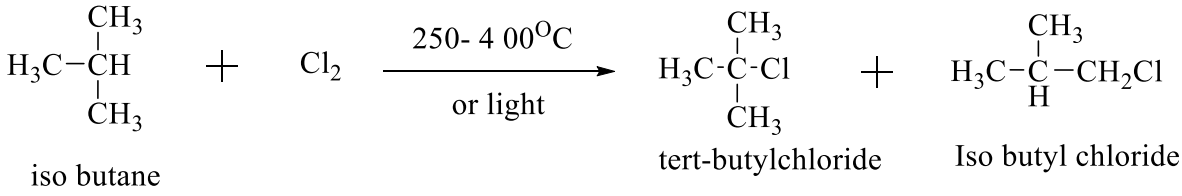
$$C_2H_6 + 7 \setminus 2\,O_2 \longrightarrow 2CO_2 + 3\,H_2O$$

2- Halogenation

Under the influence of ultraviolet light or 250- 400 ^{o}C , chlorine or bromine converts alkanes into chloro alkanes (alkyl chloride) or bromo alkanes (alkyl bromides) an equivalent amount of hydrogen chloride or hydrogen bromide is formed at the same time .



Reactivity X_2 : $Cl_2 > Br_2$ H : 3° > 2° > 1° > H_3C-H



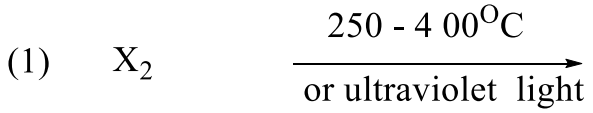
iso butane

tert-butylchloride

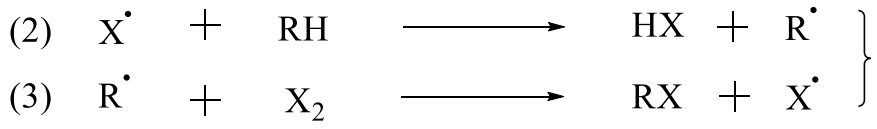
Iso butyl chloride

Mechanism of Halogenation

Halogenation of alkanes proceeds by the same mechanism as Halogenation of methane



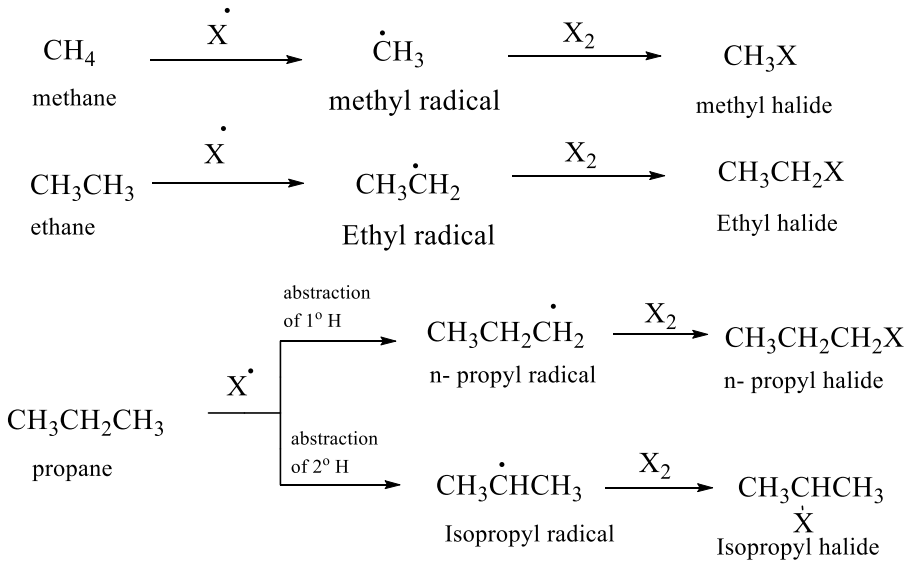
chain -initiating step



chain -propagating step

Then (2),(3), (2),(3),etc until finally a chain is terminated

A Halogen atom abstracts hydrogen form the alkane (RH) to form an alkyl radical (R`) in turn abstract a halogen atom from a halogen molecule to yield the alkyl halide (RX),Which alkyl halide is obtained depends upon which alkyl radical is formed .



Preparation of alkanes

Each of the smaller alkanes from methane through n-pentane and isopentane can be obtained in pure form by fractional distillation from petroleum and natural gas .In some of these equations the symbol **R** is used to indicate any alkyl group .

1-Hydrogenation of alkene

General method for the conversion of a carbon –carbon double bond into carbon –carbon single bond: using the same apparatus ,the condition

$$C_nH_{2n} + H_2 \xrightarrow[\text{pressure}]{\text{Ni ,Pt or Pd}} C_nH_{2n+2}$$

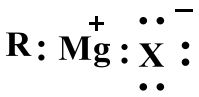
for example

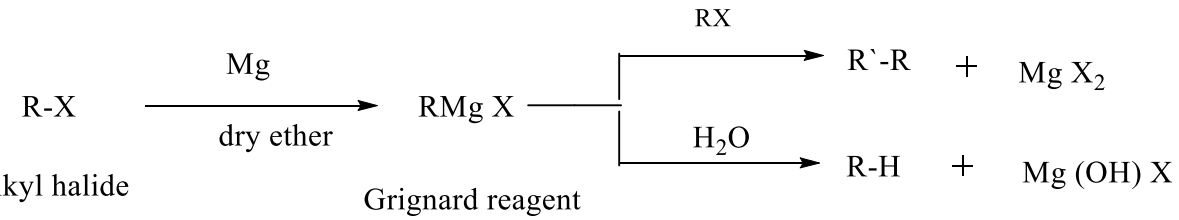
$$CH_3CH_2CH_2CH_2CH{=}CH_2 + H_2 \xrightarrow[\text{pressure}]{\text{Ni ,Pt orPd}} CH_3CH_2CH_2CH_2CH_2{-}CH_3$$

1-Hexene — n-Hexane

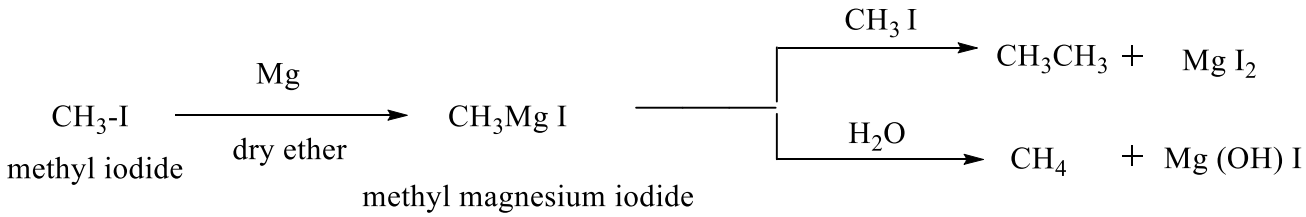
2-Grignard reagent : an organo metallic compound when a solution of an alkyl halide in dry ether $(C_2H_5)_2O$. is allowed to stand over turnings of metallic magnesium ,a vigorous reaction take place : the solution turns cloudy begins to boil and the magnesium metal gradually disappear. The resulting solution is known as a Grignard reagent. the Grignard reagent has the general formula RMgX . , and the general name **alkyl magnesium halide.** The carbon – magnesium bond is covalent but highly polar ,with carbon pulling electrons from

electropositive magnesium; the magnesium – halogen bond is essentially ionic.

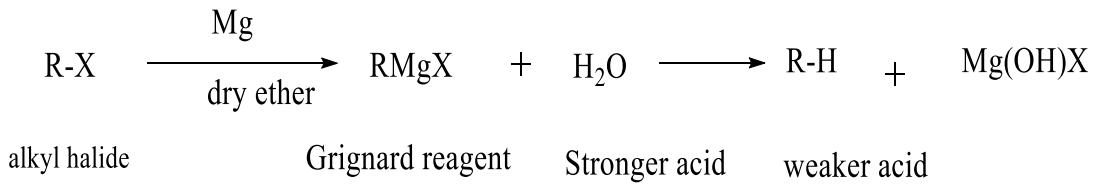


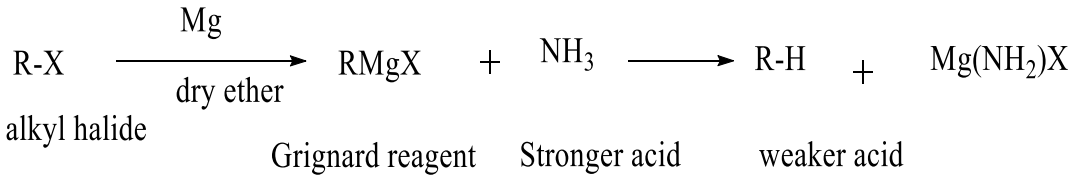


for example



The Grignard reagent is highly reactive .it reacts with numerous inorganic compounds including water ,carbon di oxide ,and oxygen and with most kinds of make particular class of organic compound .

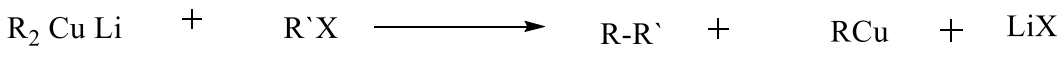




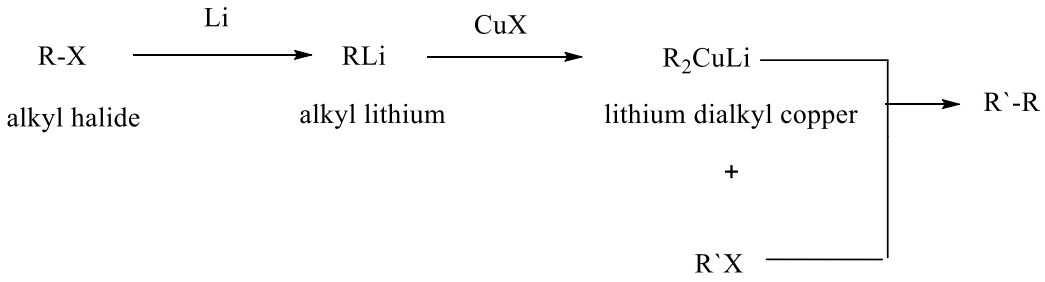
3-Coupling of alkyl halides with organometallic compound

To make alkanes of higher carbon number than the starting material requires formation of carbon –carbon bonds ,most directly by the

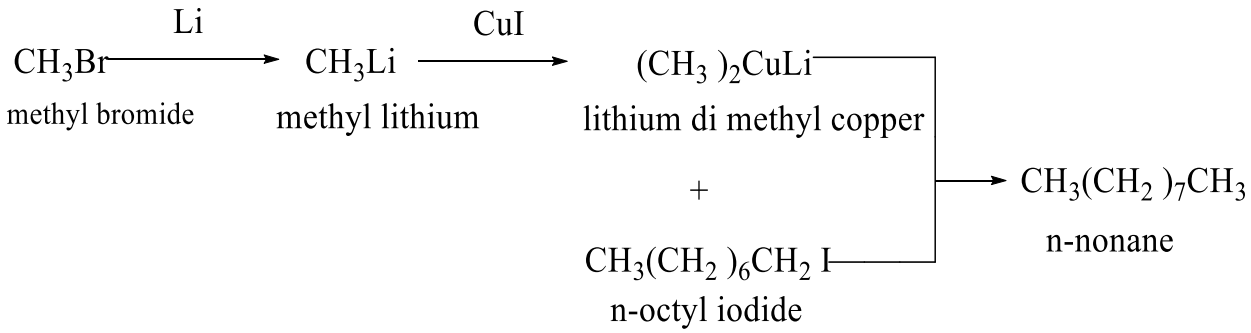
coupling together of two alkyl groups . the most method of doing this is through a synthesis by E.J .Corey and Herbert House .coupling takes place in the reaction between a lithium di alkyl copper **R_2CuLi** and alkyl halide **RX** (R stands for an alkyl group that may be the same as or different from **R**

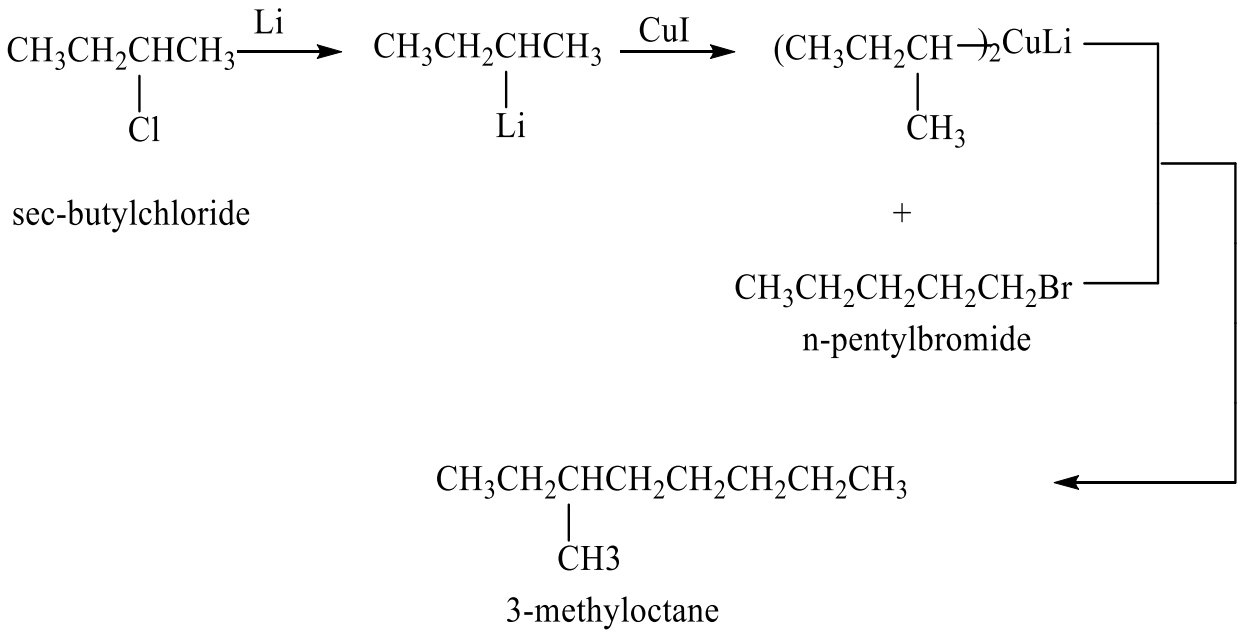


An alkyl lithium RLi is prepared for alkyl halide RX ,in much the same way as a Grignard reagent .to it is added cuprous halide .CuX and then finally the second alkyl halide, RX



For good yields ,RX should be a primary halide ,alkyl group R in the organometallic may be primary ,secondary ,or tertiary .for example :





4-Wurtz –reaction

To make alkanes by organ sodium compounds, the reaction of sodium with alkyl halides to the **symmetrical alkanes** R-R

$$2\ \text{R-X} + 2\text{Na} \longrightarrow \text{R-R} + 2\text{Na X}$$

$$2\ \text{CH}_3\text{I} + 2\text{Na} \longrightarrow \text{CH}_3\text{CH}_3 + 2\text{Na I}$$