Alkyl halides

$$\underset{\text{Alcohol}}{R-OH} + \underset{\text{Hydrogen halide}}{H-X} \longrightarrow \underset{\text{Alkyl halide}}{R-X} + \underset{\text{Water}}{H-OH}$$

$$\underset{\text{Alkane}}{R-H} + \underset{\text{Halogen}}{X_2} \longrightarrow \underset{\text{Alkyl halide}}{R-X} + \underset{\text{Hydrogen halide}}{H-X}$$

Nomenclature

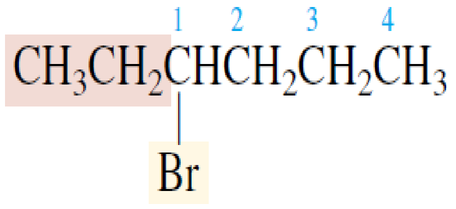
Alkyl halides

CH_3F

Methyl fluoride

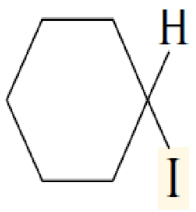
$CH_3CH_2CH_2CH_2CH_2Cl$

Pentyl chloride



$CH_3CH_2\underset{\underset{Br}{|}}{\overset{1}{C}}H\overset{2}{C}H_2\overset{3}{C}H_2\overset{4}{C}H_3$

1-Ethylbutyl bromide

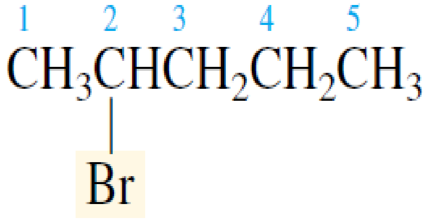


Cyclohexyl iodide

Halo alkane

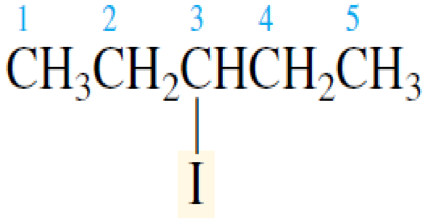
$\overset{5}{C}H_3\overset{4}{C}H_2\overset{3}{C}H_2\overset{2}{C}H_2\overset{1}{C}H_2F$

1-Fluoropentane



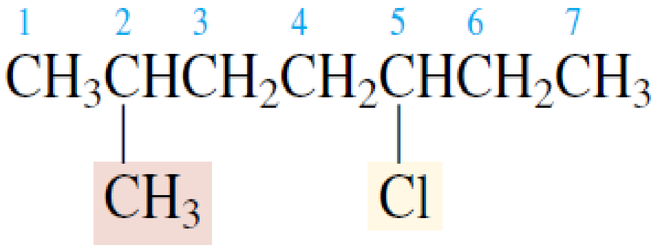
$\overset{1}{C}H_3\underset{\underset{Br}{|}}{\overset{2}{C}}H\overset{3}{C}H_2\overset{4}{C}H_2\overset{5}{C}H_3$

2-Bromopentane



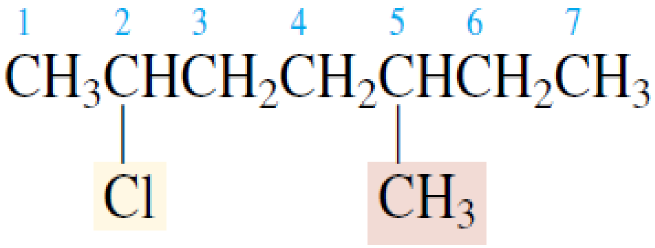
$\overset{1}{C}H_3\overset{2}{C}H_2\underset{\underset{I}{|}}{\overset{3}{C}}H\overset{4}{C}H_2\overset{5}{C}H_3$

3-Iodopentane



$$\overset{1}{CH_3}\underset{\displaystyle CH_3}{\underset{|}{\overset{2}{C}H}}\overset{3}{CH_2}\overset{4}{CH_2}\underset{\displaystyle Cl}{\underset{|}{\overset{5}{C}H}}\overset{6}{CH_2}\overset{7}{CH_3}$$

5-Chloro-2-methylheptane



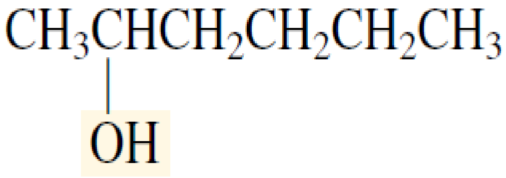
$$\overset{1}{CH_3}\underset{\displaystyle Cl}{\underset{|}{\overset{2}{C}H}}\overset{3}{CH_2}\overset{4}{CH_2}\underset{\displaystyle CH_3}{\underset{|}{\overset{5}{C}H}}\overset{6}{CH_2}\overset{7}{CH_3}$$

2-Chloro-5-methylheptane

CH_3CH_2OH

Ethyl alcohol

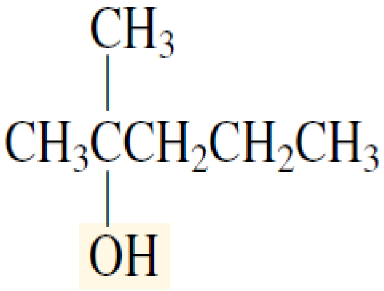
Ethanol



$$CH_3\underset{\displaystyle OH}{\underset{|}{C}H}CH_2CH_2CH_2CH_3$$

1-Methylpentyl alcohol

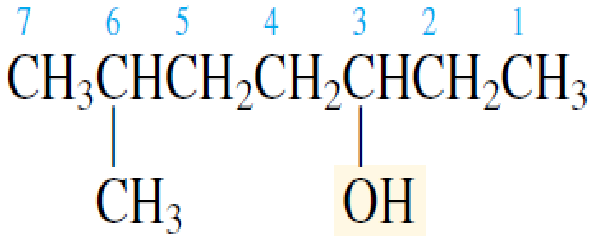
2-Hexanol



$$CH_3\overset{\displaystyle CH_3}{\underset{\displaystyle OH}{\overset{|}{\underset{|}{C}}}}CH_2CH_2CH_3$$

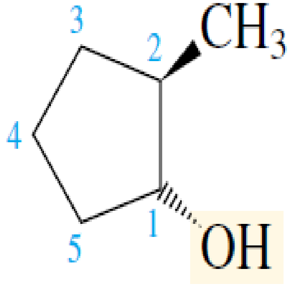
1,1-Dimethylbutyl alcohol

2-Methyl-2-pentanol



$$\overset{7}{C}H_3\underset{\displaystyle CH_3}{\overset{6}{C}H}\overset{5}{C}H_2\overset{4}{C}H_2\underset{\displaystyle OH}{\overset{3}{C}H}\overset{2}{C}H_2\overset{1}{C}H_3$$

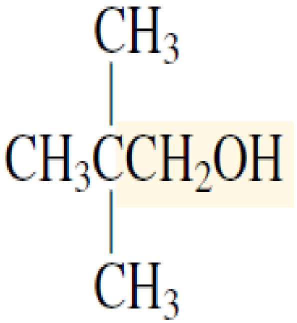
6-Methyl-3-heptanol
(not 2-methyl-5-heptanol)



trans-2-Methylcyclopentanol

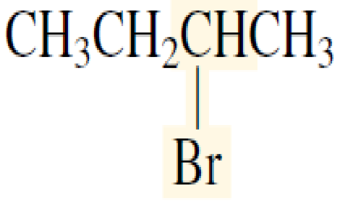
$$F\overset{3}{C}H_2\overset{2}{C}H_2\overset{1}{C}H_2OH$$

3-Fluoro-1-propanol



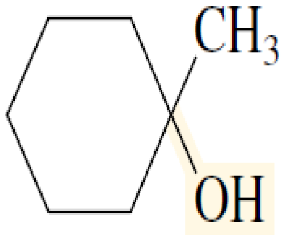
$$CH_3\underset{\displaystyle CH_3}{\overset{\displaystyle CH_3}{C}}CH_2OH$$

2,2-Dimethyl-1-propanol
(a primary alcohol)

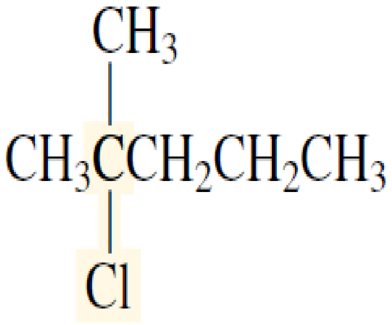


$$CH_3CH_2\underset{\displaystyle Br}{CH}CH_3$$

2-Bromobutane
(a secondary alkyl halide)

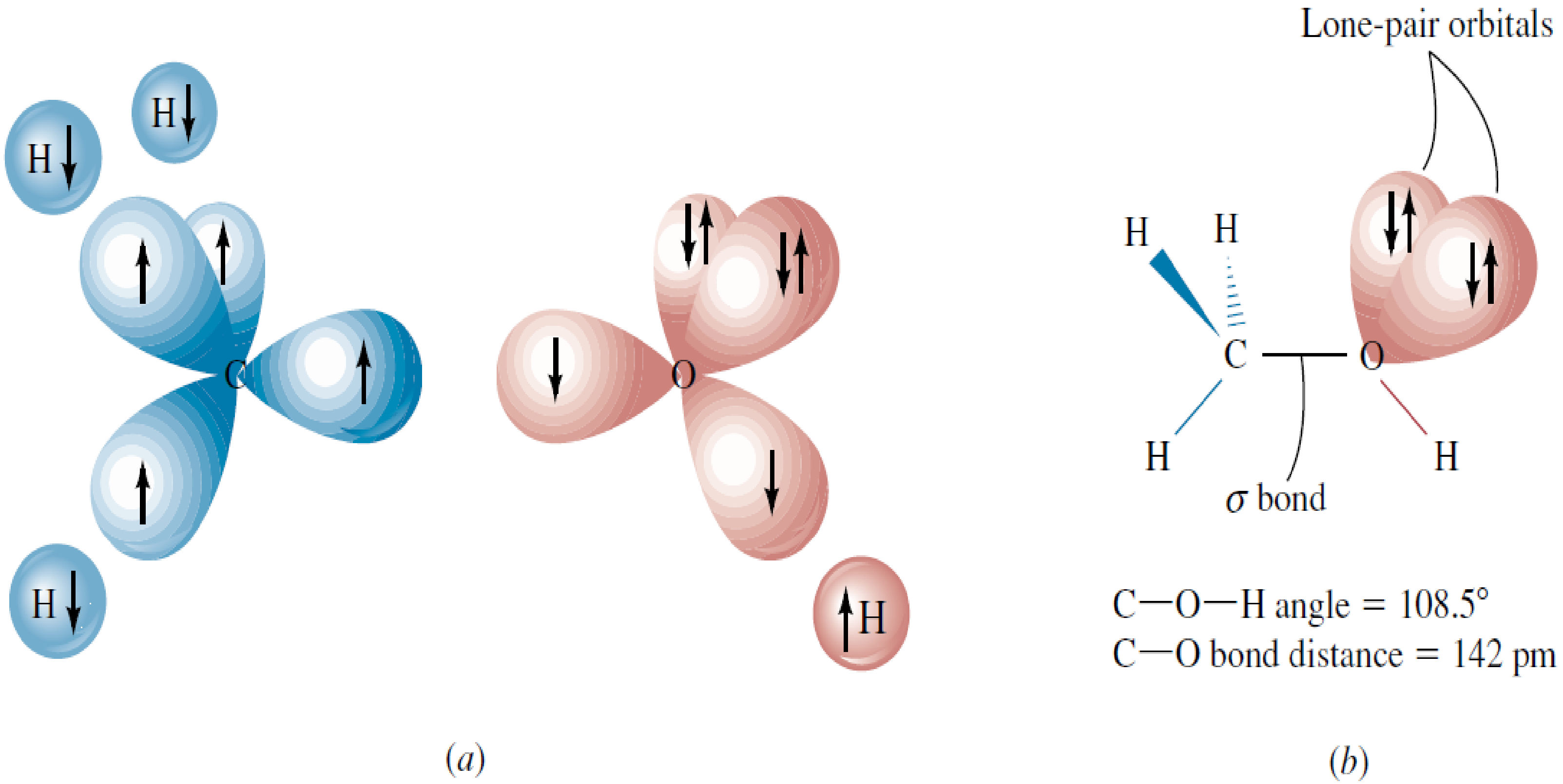


1-Methylcyclohexanol
(a tertiary alcohol)



$$CH_3\underset{\displaystyle Cl}{\overset{\displaystyle CH_3}{C}}CH_2CH_2CH_3$$

2-Chloro-2-methylpentane
(a tertiary alkyl halide)

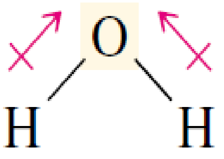


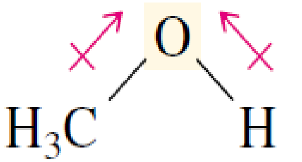
C—O—H angle = 108.5°

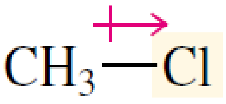
C—O bond distance = 142 pm

FIGURE 4.1 Orbital hybridization model of bonding in methanol. (*a*) The orbitals used in bonding are the 1*s* orbitals of hydrogen and sp^3-hybridized orbitals of carbon and oxygen. (*b*) The bond angles at carbon and oxygen are close to tetrahedral, and the carbon–oxygen σ bond is about 10 pm shorter than a carbon–carbon single bond.

Dipole moment


Water
(μ = 1.8 D)


Methanol
(μ = 1.7 D)


$CH_3—Cl$

Chloromethane
(μ = 1.9 D)

	CH_3Cl	CH_2Cl_2	$CHCl_3$	CCl_4
	Chloromethane (methyl chloride)	Dichloromethane (methylene dichloride)	Trichloromethane (chloroform)	Tetrachloromethane (carbon tetrachloride)
Boiling point:	−24°C	40°C	61°C	77°C

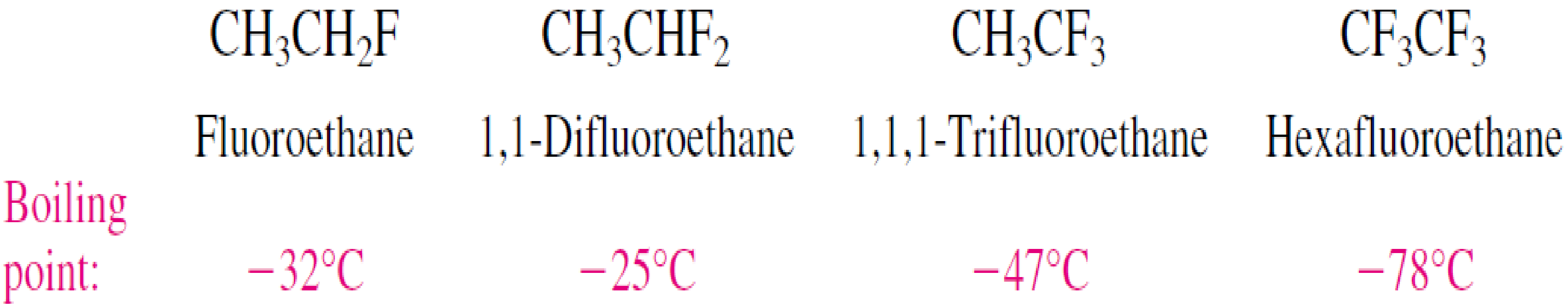
Dipole/ induced-dipole forces

Dipole-dipole attractive forces

Hydrogen bond

$CH_3CH_2CH_3$	CH_3CH_2OH	CH_3CH_2F
Propane (μ = 0 D)	Ethanol (μ = 1.7 D)	Fluoroethane (μ = 1.9 D)
bp: −42°C	bp: 78°C	bp: −32°C

Low polarizability



	CH_3CH_2F	CH_3CHF_2	CH_3CF_3	CF_3CF_3
	Fluoroethane	1,1-Difluoroethane	1,1,1-Trifluoroethane	Hexafluoroethane
Boiling point:	−32°C	−25°C	−47°C	−78°C

Solubility in water: alkyl halides have low solubility but alcohols have high solubility

Density: CH_3F and CH_3Cl are less dense than H_2O.

Acids

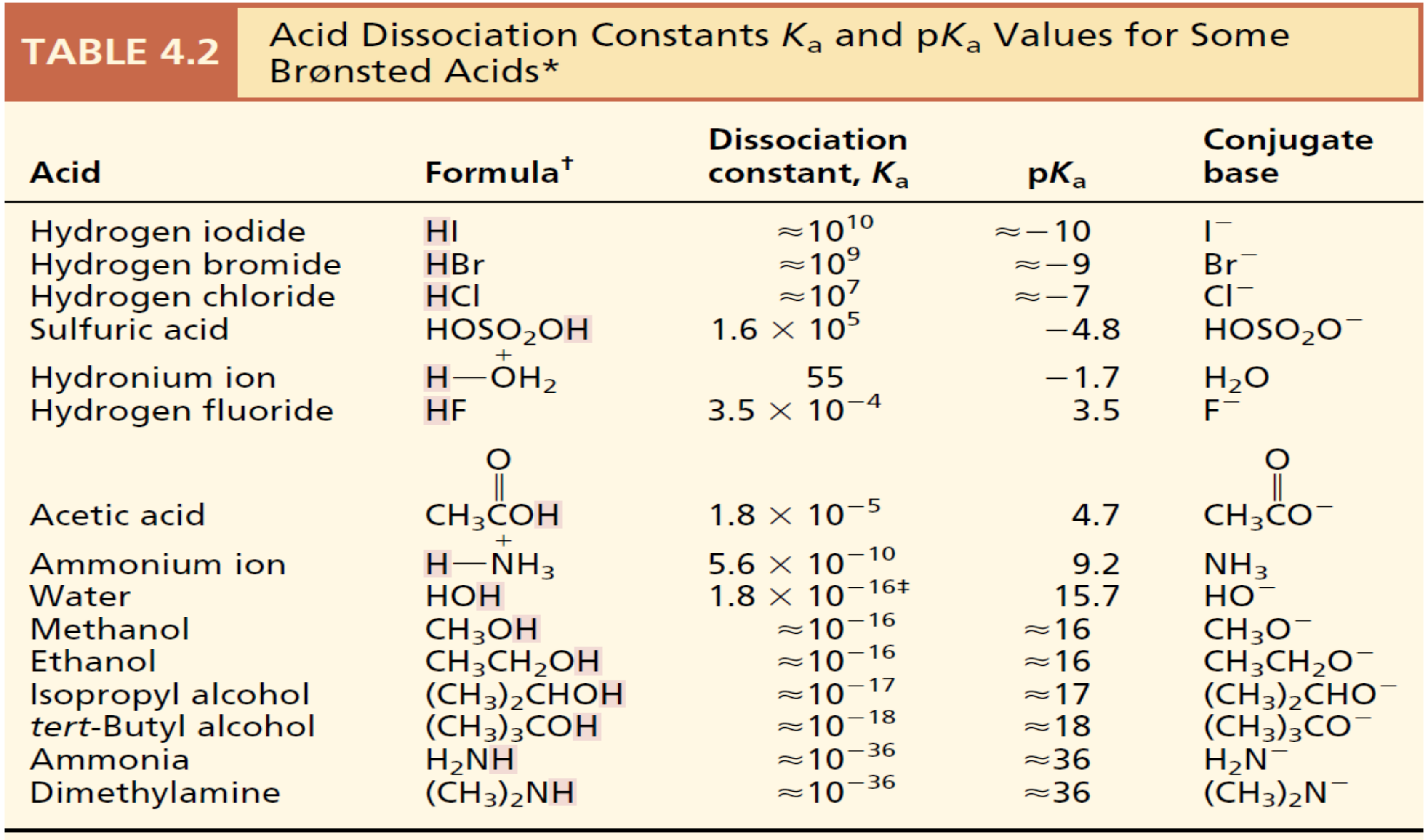
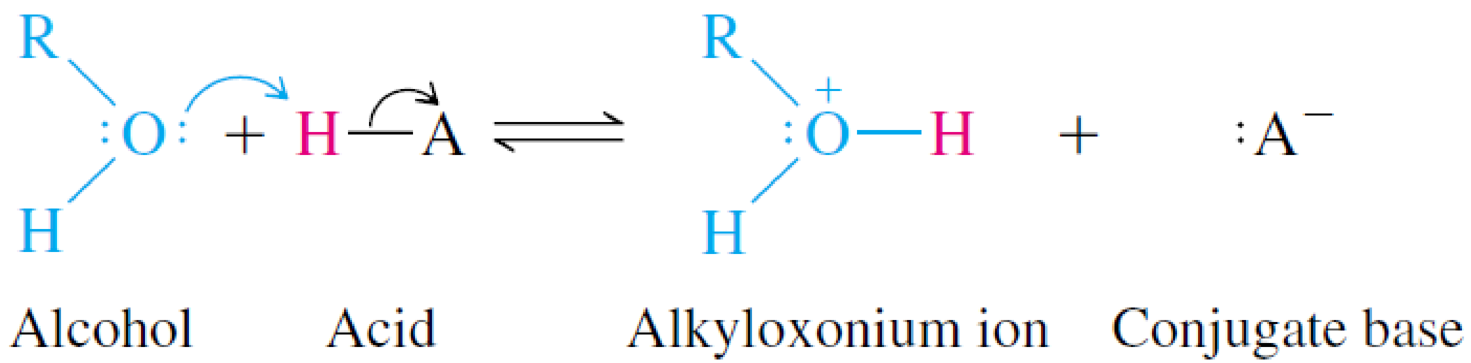
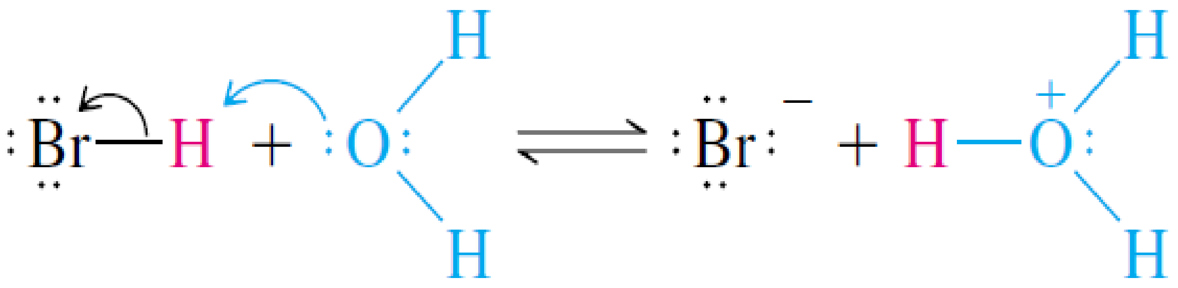


TABLE 4.2 Acid Dissociation Constants K_a and pK_a Values for Some Brønsted Acids*

Acid	Formula†	Dissociation constant, K_a	pK_a	Conjugate base
Hydrogen iodide	HI	$\approx 10^{10}$	≈ -10	I^-
Hydrogen bromide	HBr	$\approx 10^{9}$	≈ -9	Br^-
Hydrogen chloride	HCl	$\approx 10^{7}$	≈ -7	Cl^-
Sulfuric acid	$HOSO_2OH$	1.6×10^{5}	-4.8	$HOSO_2O^-$
Hydronium ion	$H{-}\overset{+}{O}H_2$	55	-1.7	H_2O
Hydrogen fluoride	HF	3.5×10^{-4}	3.5	F^-
Acetic acid	$CH_3\overset{\overset{O}{\parallel}}{C}OH$	1.8×10^{-5}	4.7	$CH_3\overset{\overset{O}{\parallel}}{C}O^-$
Ammonium ion	$H{-}\overset{+}{N}H_3$	5.6×10^{-10}	9.2	NH_3
Water	HOH	$1.8 \times 10^{-16‡}$	15.7	HO^-
Methanol	CH_3OH	$\approx 10^{-16}$	≈ 16	CH_3O^-
Ethanol	CH_3CH_2OH	$\approx 10^{-16}$	≈ 16	$CH_3CH_2O^-$
Isopropyl alcohol	$(CH_3)_2CHOH$	$\approx 10^{-17}$	≈ 17	$(CH_3)_2CHO^-$
tert-Butyl alcohol	$(CH_3)_3COH$	$\approx 10^{-18}$	≈ 18	$(CH_3)_3CO^-$
Ammonia	H_2NH	$\approx 10^{-36}$	≈ 36	H_2N^-
Dimethylamine	$(CH_3)_2NH$	$\approx 10^{-36}$	≈ 36	$(CH_3)_2N^-$

$$\text{Stronger acid} + \text{stronger base} \overset{K>1}{\rightleftharpoons} \text{weaker acid} + \text{weaker base}$$





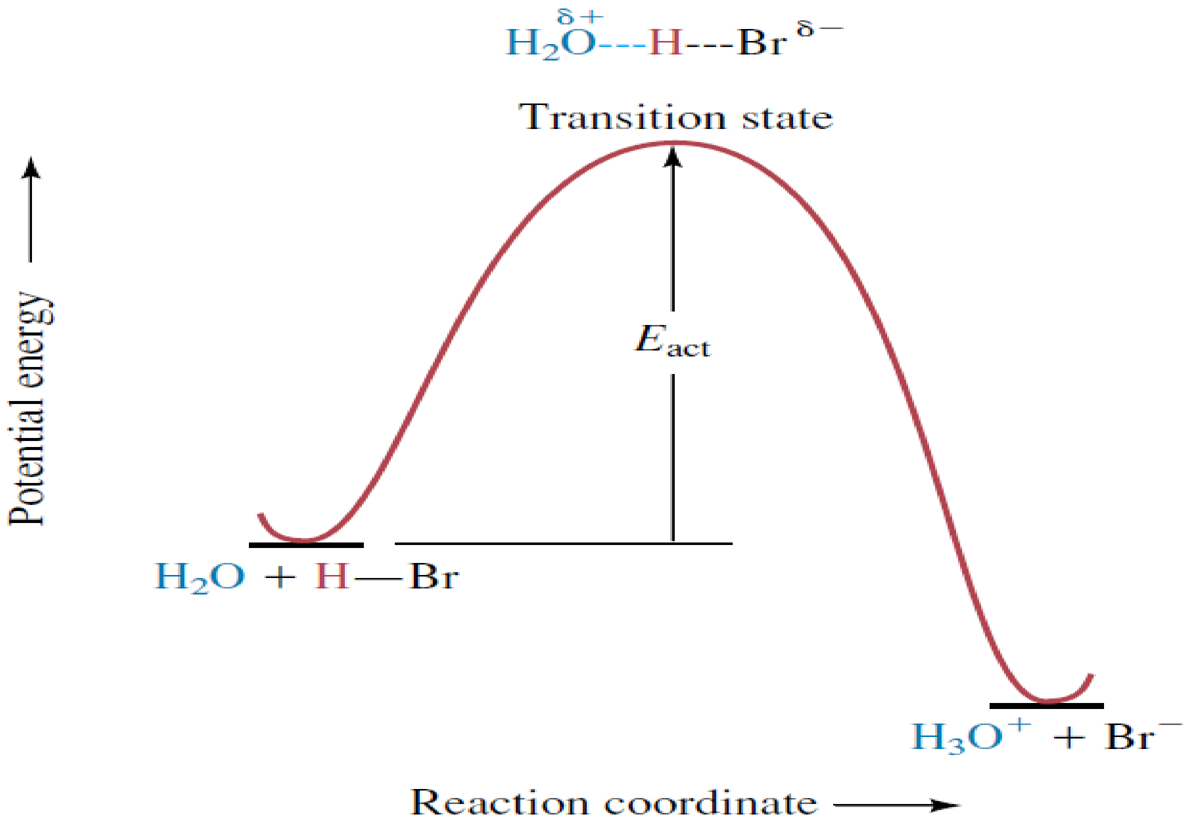


FIGURE 4.6 Energy diagram for concerted bimolecular proton transfer from hydrogen bromide to water.

Preparation of alkyl halides from alcohols

$$\mathrm{R{-}OH} + \mathrm{H{-}X} \longrightarrow \mathrm{R{-}X} + \mathrm{H{-}OH}$$

Alcohol	Hydrogen halide	Alkyl halide	Water

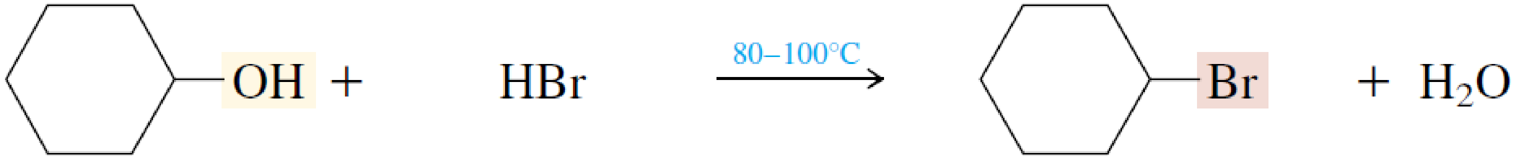
Increasing reactivity of alcohols toward hydrogen halides

$$\mathrm{CH_3OH} < \mathrm{RCH_2OH} < \mathrm{R_2CHOH} < \mathrm{R_3COH}$$

CH_3OH	RCH_2OH	R_2CHOH	R_3COH
Methyl Least reactive	Primary	Secondary	Tertiary Most reactive

$$(CH_3)_3COH + HCl \xrightarrow{25°C} (CH_3)_3CCl + H_2O$$

2-Methyl-2-propanol (*tert*-butyl alcohol)
Hydrogen chloride
2-Chloro-2-methylpropane (*tert*-butyl chloride) (78–88%)
Water



Cyclohexanol
Hydrogen bromide
Bromocyclohexane (73%)
Water

$$CH_3(CH_2)_5CH_2OH + HBr \xrightarrow{120°C} CH_3(CH_2)_5CH_2Br + H_2O$$

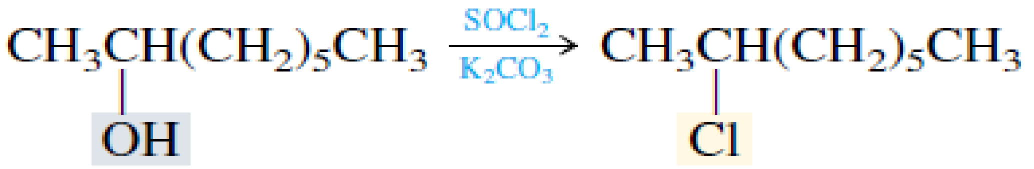
1-Heptanol
Hydrogen bromide
1-Bromoheptane (87–90%)
Water

$$CH_3CH_2CH_2CH_2OH \xrightarrow[\text{heat}]{NaBr,\ H_2SO_4} CH_3CH_2CH_2CH_2Br$$

1-Butanol (*n*-butyl alcohol)
1-Bromobutane (70–83%) (*n*-butyl bromide)

$$ROH + SOCl_2 \longrightarrow RCl + SO_2 + HCl$$

Alcohol	Thionyl chloride	Alkyl chloride	Sulfur dioxide	Hydrogen chloride

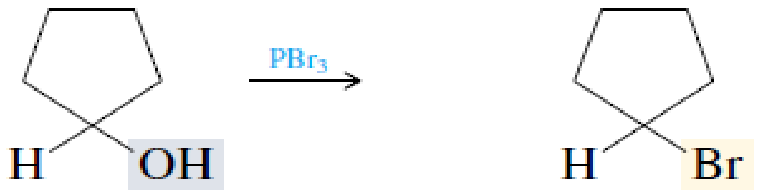


$$CH_3\underset{\displaystyle OH}{CH}(CH_2)_5CH_3 \xrightarrow[K_2CO_3]{SOCl_2} CH_3\underset{\displaystyle Cl}{CH}(CH_2)_5CH_3$$

2-Octanol 2-Chlorooctane (81%)

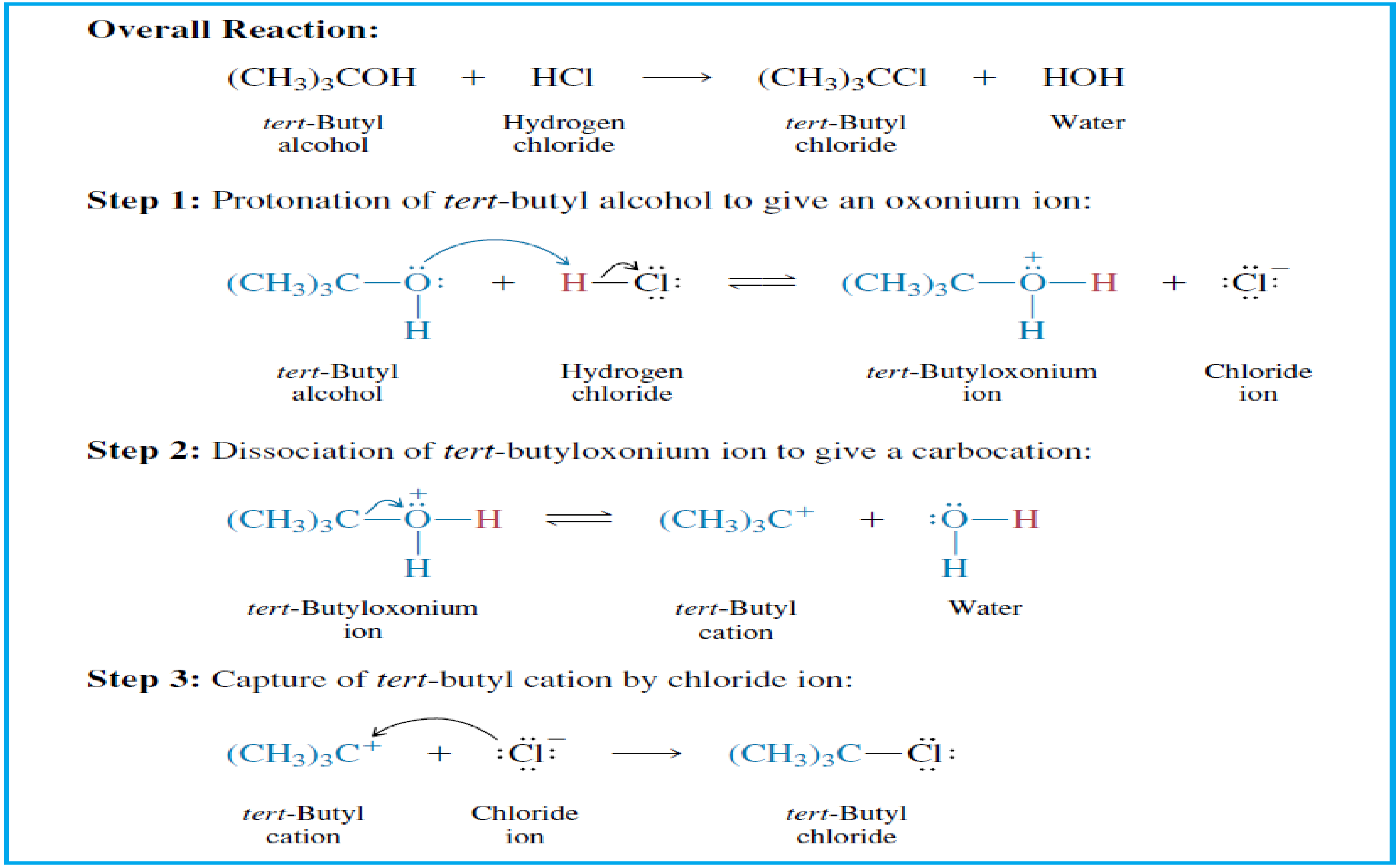
$$3ROH + PBr_3 \longrightarrow 3RBr + H_3PO_3$$

Alcohol	Phosphorus tribromide	Alkyl bromide	Phosphorous acid



Cyclopentanol Cyclopentyl bromide (78–84%)

Mechanism: Carbocation (Intermediate)



Overall Reaction:

$$(CH_3)_3COH + HCl \longrightarrow (CH_3)_3CCl + HOH$$

tert-Butyl alcohol; Hydrogen chloride; *tert*-Butyl chloride; Water

Step 1: Protonation of *tert*-butyl alcohol to give an oxonium ion:

$$(CH_3)_3C-\underset{H}{\overset{..}{O}}: + H-\overset{..}{\underset{..}{Cl}}: \rightleftharpoons (CH_3)_3C-\underset{H}{\overset{+}{\overset{..}{O}}}-H + :\overset{..}{\underset{..}{Cl}}:^{-}$$

tert-Butyl alcohol; Hydrogen chloride; *tert*-Butyloxonium ion; Chloride ion

Step 2: Dissociation of *tert*-butyloxonium ion to give a carbocation:

$$(CH_3)_3C-\underset{H}{\overset{+}{\overset{..}{O}}}-H \rightleftharpoons (CH_3)_3C^{+} + :\underset{H}{\overset{..}{O}}-H$$

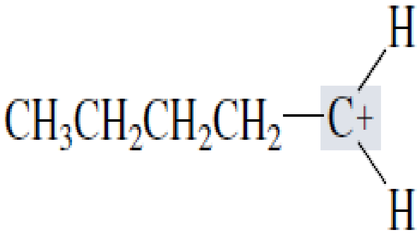
tert-Butyloxonium ion; *tert*-Butyl cation; Water

Step 3: Capture of *tert*-butyl cation by chloride ion:

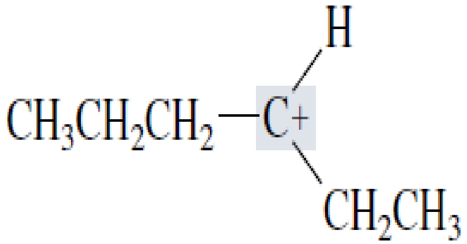
$$(CH_3)_3C^{+} + :\overset{..}{\underset{..}{Cl}}:^{-} \longrightarrow (CH_3)_3C-\overset{..}{\underset{..}{Cl}}:$$

tert-Butyl cation; Chloride ion; *tert*-Butyl chloride

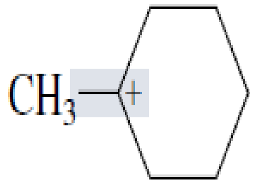
Structure, bonding and stability of carbocation



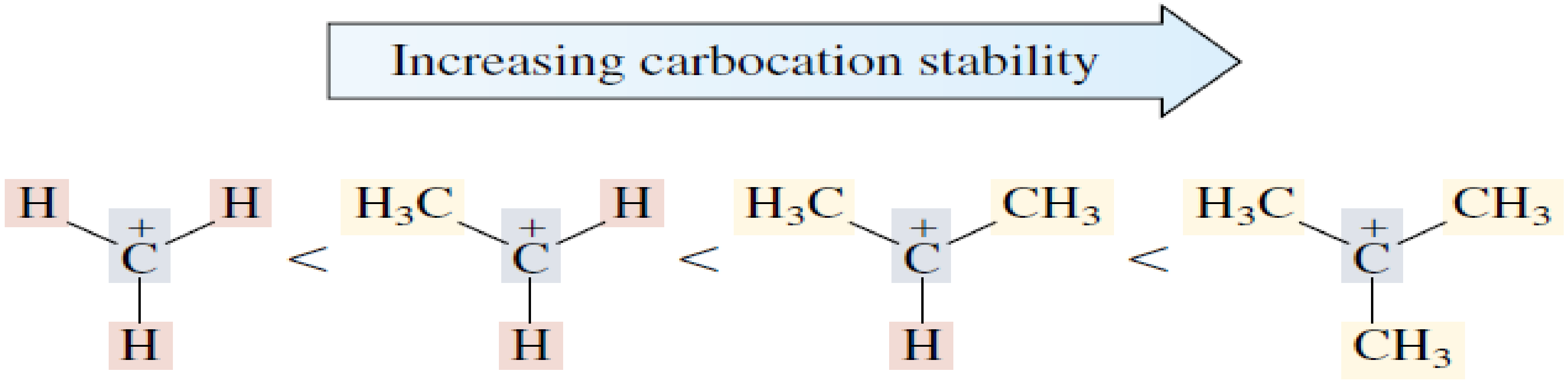
Pentyl cation
(primary carbocation)



1-Ethylbutyl cation
(secondary carbocation)



1-Methylcyclohexyl cation
(tertiary carbocation)



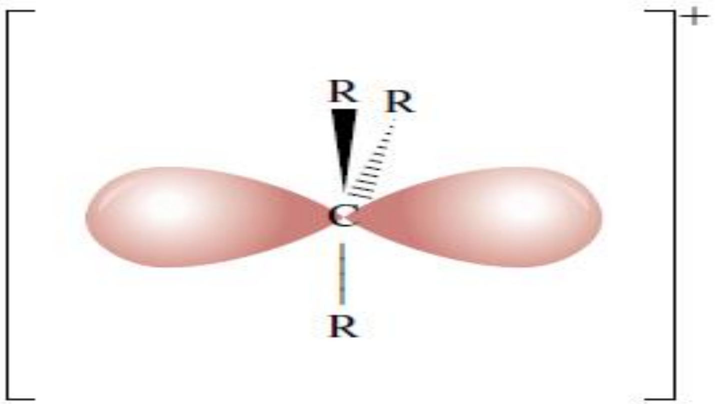
Methyl cation
Least stable

Ethyl cation
(primary)

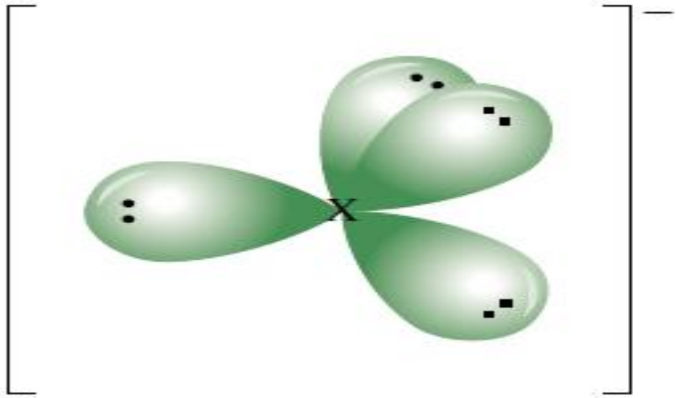
Isopropyl cation
(secondary)

tert-Butyl cation
(tertiary)
Most stable

Inductive effect; Hyperconjugation; Angle strain and steric effect; Electrophile; Nucleophile



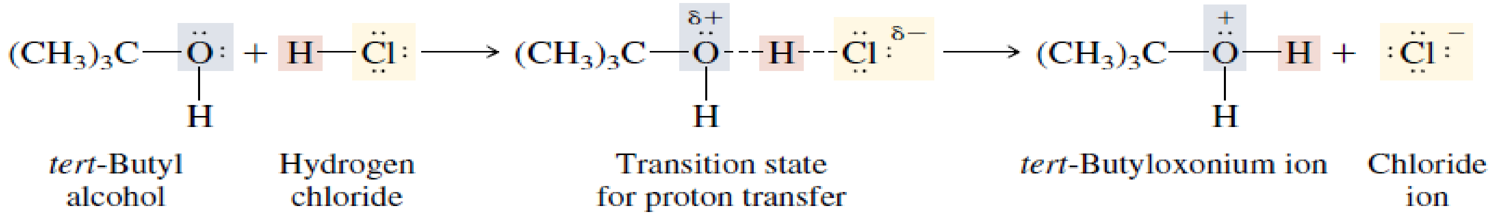
Carbocation
(electrophile)



Halide anion
(nucleophile)

Alkyl halide

Potential energy: S_N1 mechanism



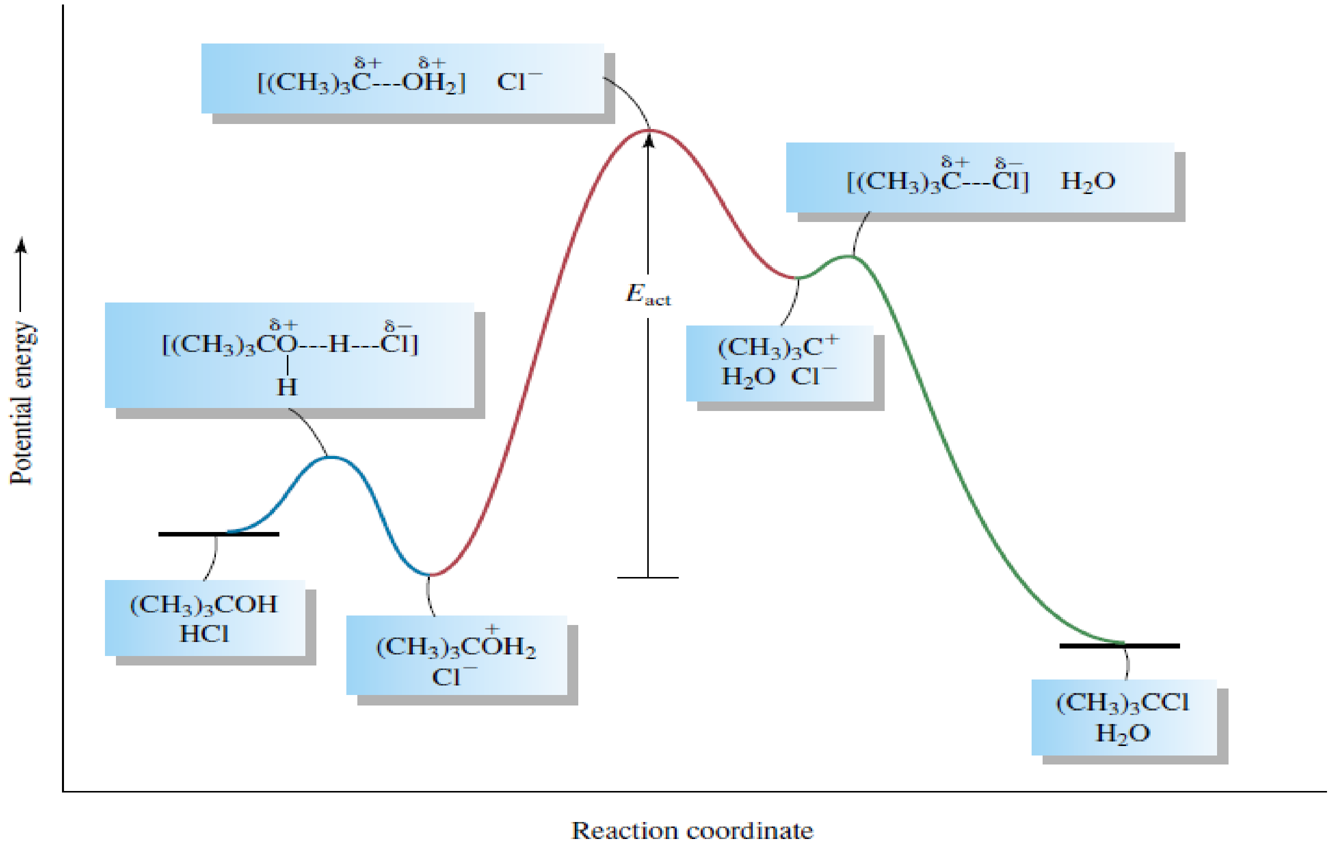
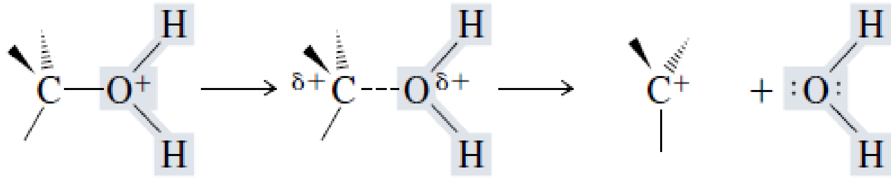


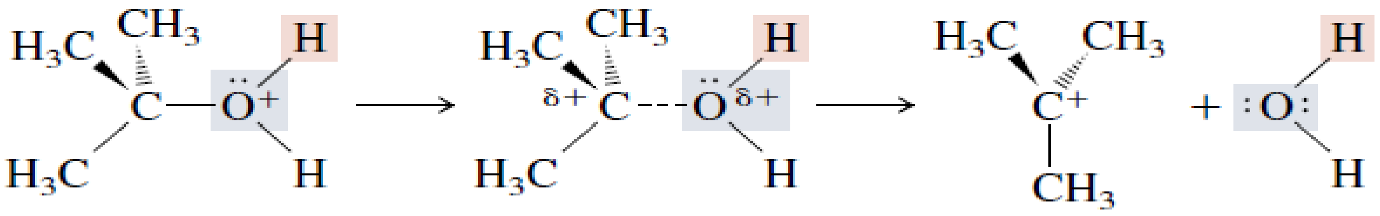
FIGURE 4.13 Energy diagram depicting the intermediates and transition states involved in the reaction of *tert*-butyl alcohol with hydrogen chloride.

Unimolecular: Rate determining step:

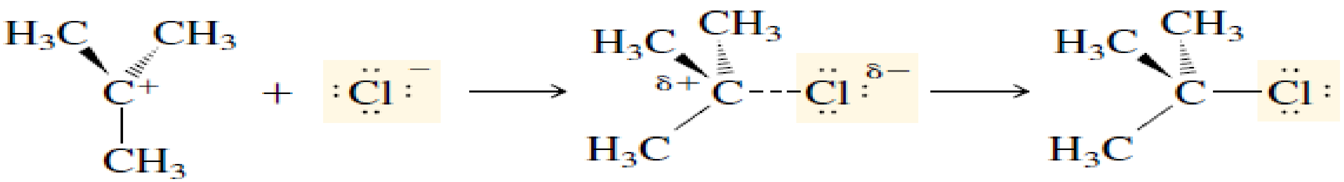
$$\text{Rate} = k[\text{alkyloxonium ion}]$$



Alkyloxonium ion — Transition state — Carbocation — Water

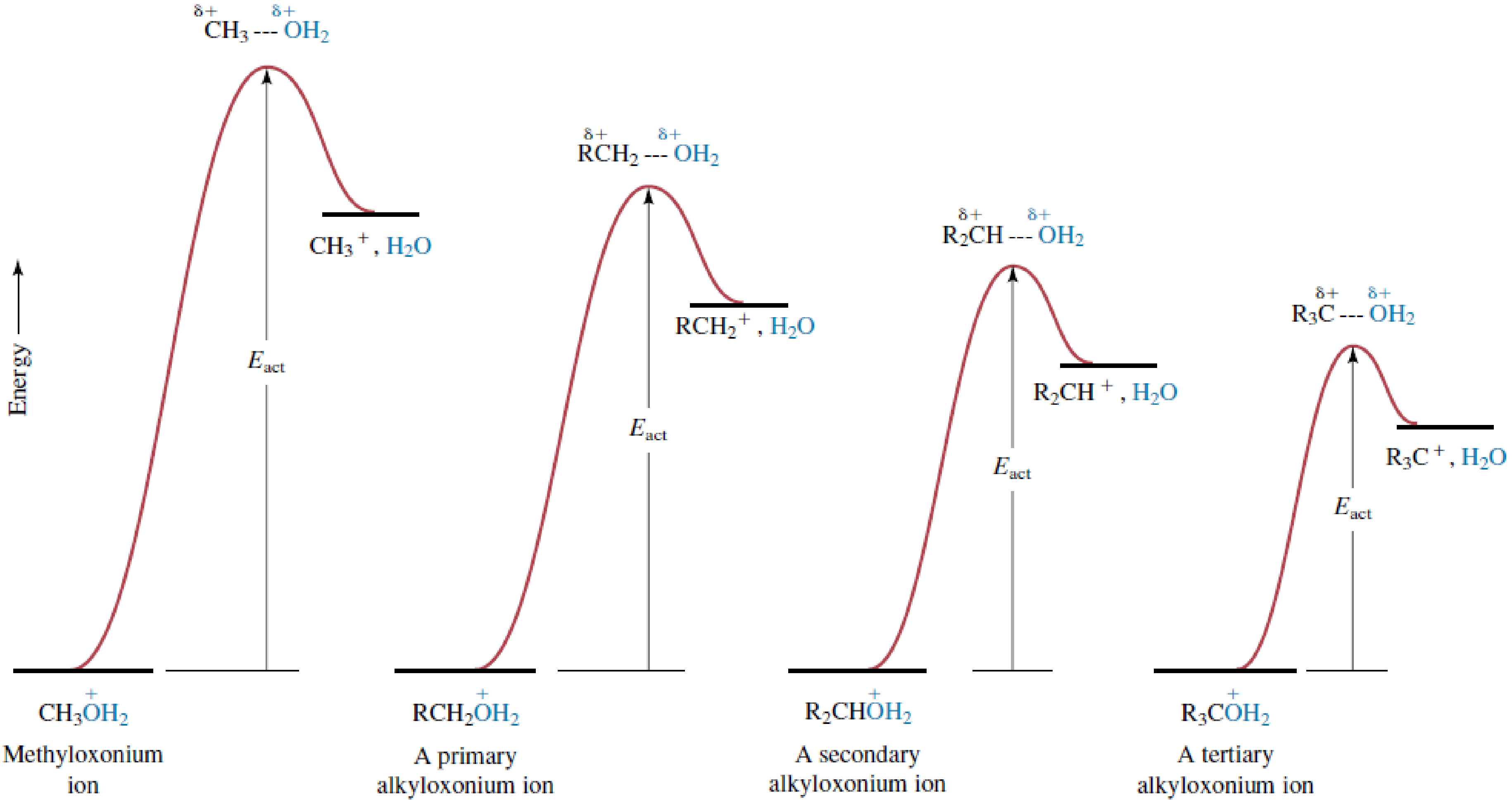


tert-Butyloxonium ion — Transition state for dissociation of alkyloxonium ion — *tert*-Butyl cation — Water



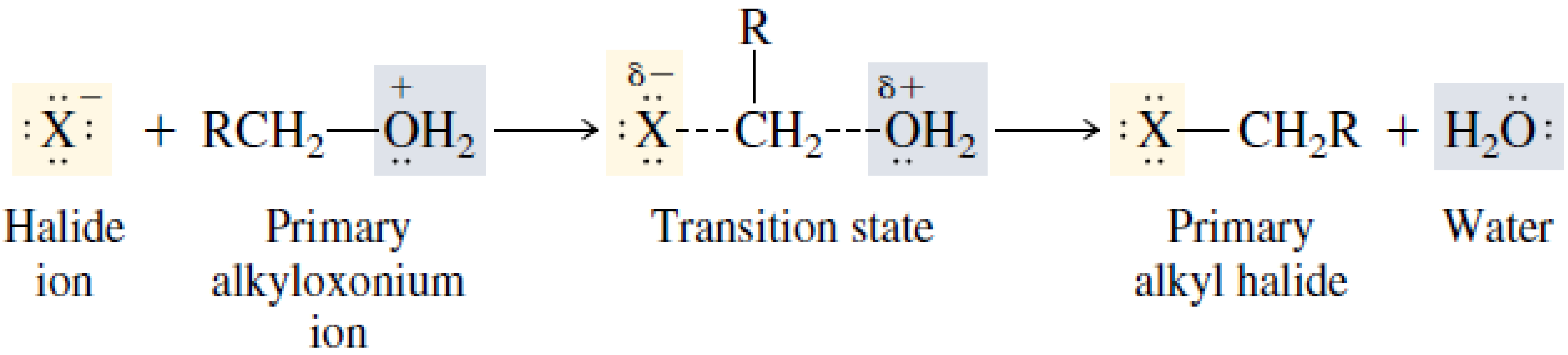
tert-Butyl cation — Chloride anion — Transition state for cation–anion combination — *tert*-Butyl chloride

Hammond’s postulate



S_N2 mechanism

Bimolecular: Concerted reaction



$$:\ddot{\underset{..}{X}}:^{-} + RCH_2\text{—}\overset{+}{\ddot{O}}H_2 \longrightarrow \overset{\delta-}{:\underset{..}{\ddot{X}}}\text{- - -}\overset{\overset{\displaystyle R}{|}}{CH_2}\text{- - -}\overset{\delta+}{\underset{..}{O}}H_2 \longrightarrow :\underset{..}{\ddot{X}}\text{—}CH_2R + H_2\ddot{O}:$$

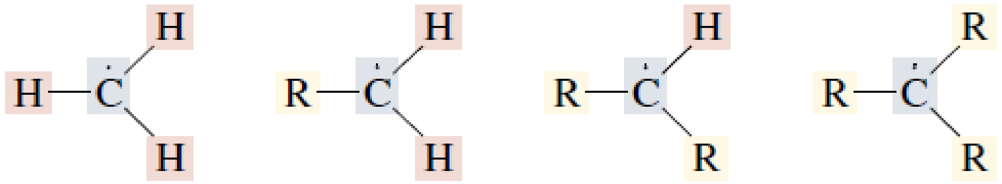
$$\underset{\text{Alkane}}{R{-}H} + \underset{\text{Halogen}}{X_2} \longrightarrow \underset{\text{Alkyl halide}}{R{-}X} + \underset{\text{Hydrogen halide}}{H{-}X}$$

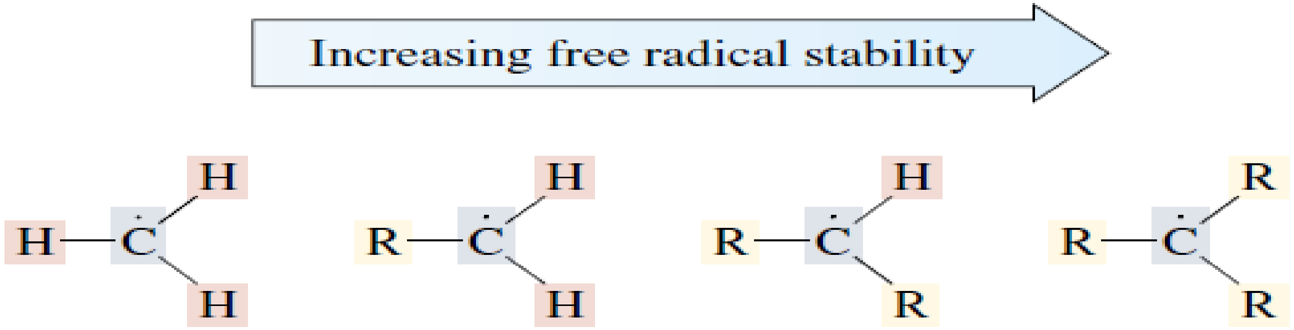
$$\underset{\text{Methane}}{CH_4} + \underset{\text{Chlorine}}{Cl_2} \xrightarrow{400\text{–}440^\circ C} \underset{\substack{\text{Chloromethane}\\ \text{(bp } -24^\circ\text{C)}}}{CH_3Cl} + \underset{\substack{\text{Hydrogen}\\ \text{chloride}}}{HCl}$$

$$\underset{\text{Chloromethane}}{CH_3Cl} + \underset{\text{Chlorine}}{Cl_2} \xrightarrow{400\text{–}440^\circ C} \underset{\substack{\text{Dichloromethane}\\ \text{(bp } 40^\circ\text{C)}}}{CH_2Cl_2} + \underset{\substack{\text{Hydrogen}\\ \text{chloride}}}{HCl}$$

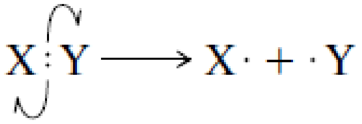
$$\underset{\text{Dichloromethane}}{CH_2Cl_2} + \underset{\text{Chlorine}}{Cl_2} \xrightarrow{400\text{–}440^\circ C} \underset{\substack{\text{Trichloromethane}\\ \text{(bp } 61^\circ\text{C)}}}{CHCl_3} + \underset{\substack{\text{Hydrogen}\\ \text{chloride}}}{HCl}$$

$$\underset{\text{Trichloromethane}}{CHCl_3} + \underset{\text{Chlorine}}{Cl_2} \xrightarrow{400\text{–}440^\circ C} \underset{\substack{\text{Tetrachloromethane}\\ \text{(bp } 77^\circ\text{C)}}}{CCl_4} + \underset{\substack{\text{Hydrogen}\\ \text{chloride}}}{HCl}$$


Methyl radical
Primary radical
Secondary radical
Tertiary radical


Increasing free radical stability
Methyl radical
(least stable)
Primary radical
Secondary radical
Tertiary radical
(most stable)

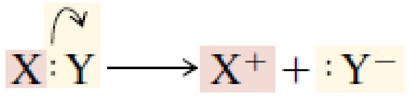
A curved arrow shown as a single-barbed fishhook signifies the movement of *one* electron. “Normal” curved arrows track the movement of a *pair* of electrons.



$$X{:}Y \longrightarrow X\cdot + \cdot Y$$

Homolytic bond cleavage

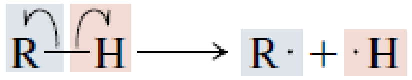
In contrast, in a **heterolytic cleavage** one fragment retains both electrons.



$$X{:}Y \longrightarrow X^{+} + {:}Y^{-}$$

Heterolytic bond cleavage

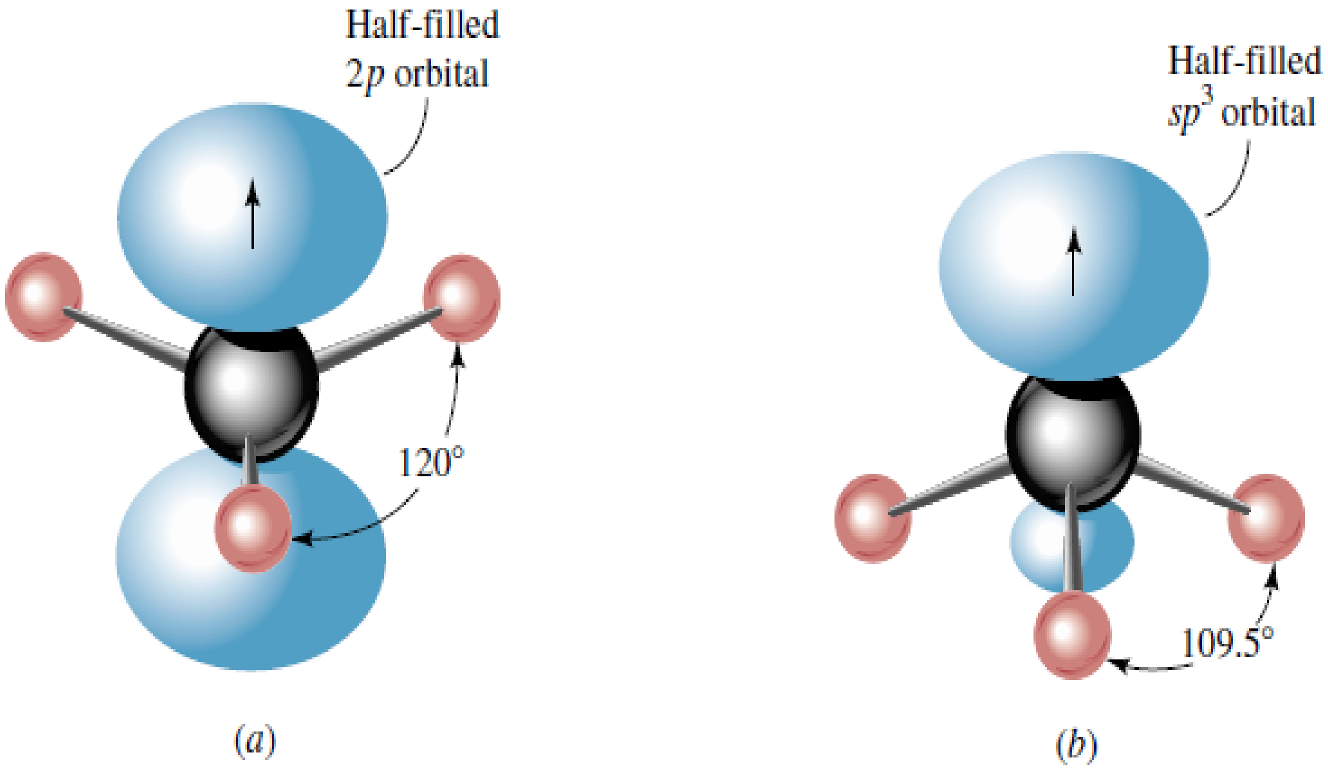
We assess the relative stability of alkyl radicals by measuring the enthalpy change ($\Delta H°$) for the homolytic cleavage of a C—H bond in an alkane:



$$R{-}H \longrightarrow R\cdot + \cdot H$$

The more stable the radical, the lower the energy required to generate it by C—H bond homolysis.

FIGURE 4.15 Orbital hybridization models of bonding in methyl radical. (*a*) If the structure of the CH_3 radical is planar, then carbon is sp^2-hybridized with an unpaired electron in a 2*p* orbital. (*b*) If CH_3 is pyramidal, carbon is sp^3-hybridized with an electron in an sp^3 orbital. Model (*a*) is more consistent with experimental observations.



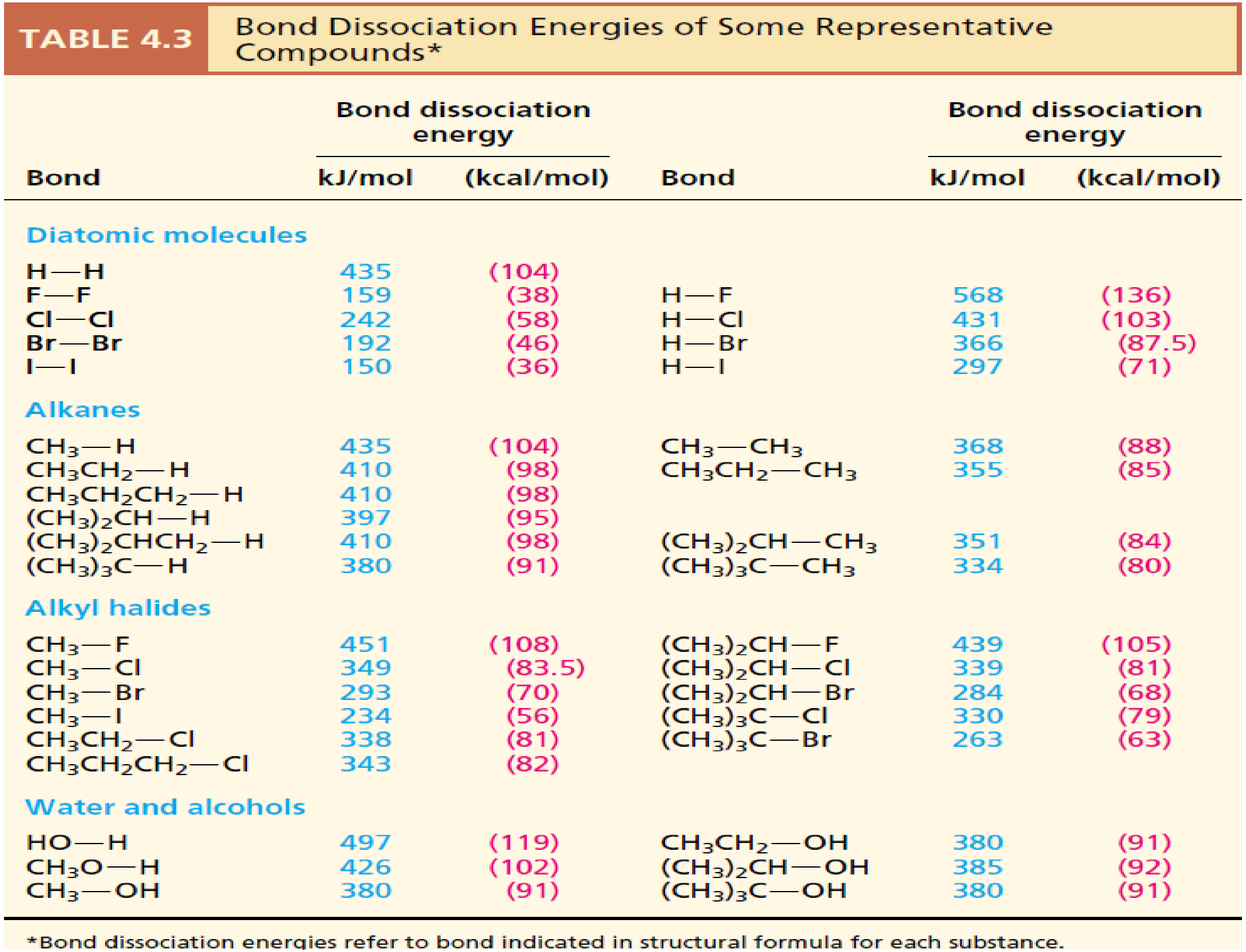


TABLE 4.3 Bond Dissociation Energies of Some Representative Compounds*

	Bond dissociation energy			Bond dissociation energy	
Bond	kJ/mol	(kcal/mol)	Bond	kJ/mol	(kcal/mol)
Diatomic molecules					
$H{-}H$	435	(104)			
$F{-}F$	159	(38)	$H{-}F$	568	(136)
$Cl{-}Cl$	242	(58)	$H{-}Cl$	431	(103)
$Br{-}Br$	192	(46)	$H{-}Br$	366	(87.5)
$I{-}I$	150	(36)	$H{-}I$	297	(71)
Alkanes					
$CH_3{-}H$	435	(104)	$CH_3{-}CH_3$	368	(88)
$CH_3CH_2{-}H$	410	(98)	$CH_3CH_2{-}CH_3$	355	(85)
$CH_3CH_2CH_2{-}H$	410	(98)			
$(CH_3)_2CH{-}H$	397	(95)			
$(CH_3)_2CHCH_2{-}H$	410	(98)	$(CH_3)_2CH{-}CH_3$	351	(84)
$(CH_3)_3C{-}H$	380	(91)	$(CH_3)_3C{-}CH_3$	334	(80)
Alkyl halides					
$CH_3{-}F$	451	(108)	$(CH_3)_2CH{-}F$	439	(105)
$CH_3{-}Cl$	349	(83.5)	$(CH_3)_2CH{-}Cl$	339	(81)
$CH_3{-}Br$	293	(70)	$(CH_3)_2CH{-}Br$	284	(68)
$CH_3{-}I$	234	(56)	$(CH_3)_3C{-}Cl$	330	(79)
$CH_3CH_2{-}Cl$	338	(81)	$(CH_3)_3C{-}Br$	263	(63)
$CH_3CH_2CH_2{-}Cl$	343	(82)			
Water and alcohols					
$HO{-}H$	497	(119)	$CH_3CH_2{-}OH$	380	(91)
$CH_3O{-}H$	426	(102)	$(CH_3)_2CH{-}OH$	385	(92)
$CH_3{-}OH$	380	(91)	$(CH_3)_3C{-}OH$	380	(91)

*Bond dissociation energies refer to bond indicated in structural formula for each substance.

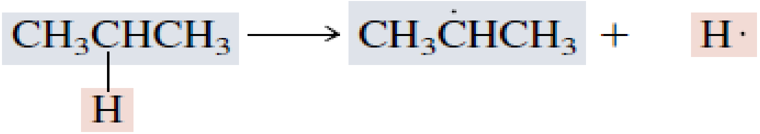
Bond dissociation energy

$CH_3CH_2CH_2{-}H \longrightarrow CH_3CH_2\dot{C}H_2 + H\cdot$ $\Delta H^\circ = +410$ kJ (98 kcal)

Propane

n-Propyl radical (primary)

Hydrogen atom

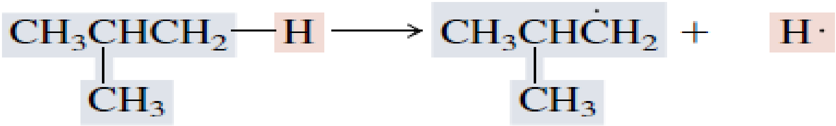


$CH_3\underset{\substack{|\\ H}}{C}HCH_3 \longrightarrow CH_3\dot{C}HCH_3 + H\cdot$ $\Delta H^\circ = +397$ kJ (95 kcal)

Propane

Isopropyl radical (secondary)

Hydrogen atom

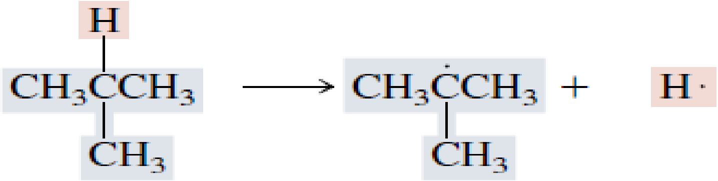


$CH_3\underset{\substack{|\\ CH_3}}{C}HCH_2{-}H \longrightarrow CH_3\underset{\substack{|\\ CH_3}}{C}H\dot{C}H_2 + H\cdot$ $\Delta H^\circ = +410$ kJ (98 kcal)

2-Methylpropane

Isobutyl radical (primary)

Hydrogen atom

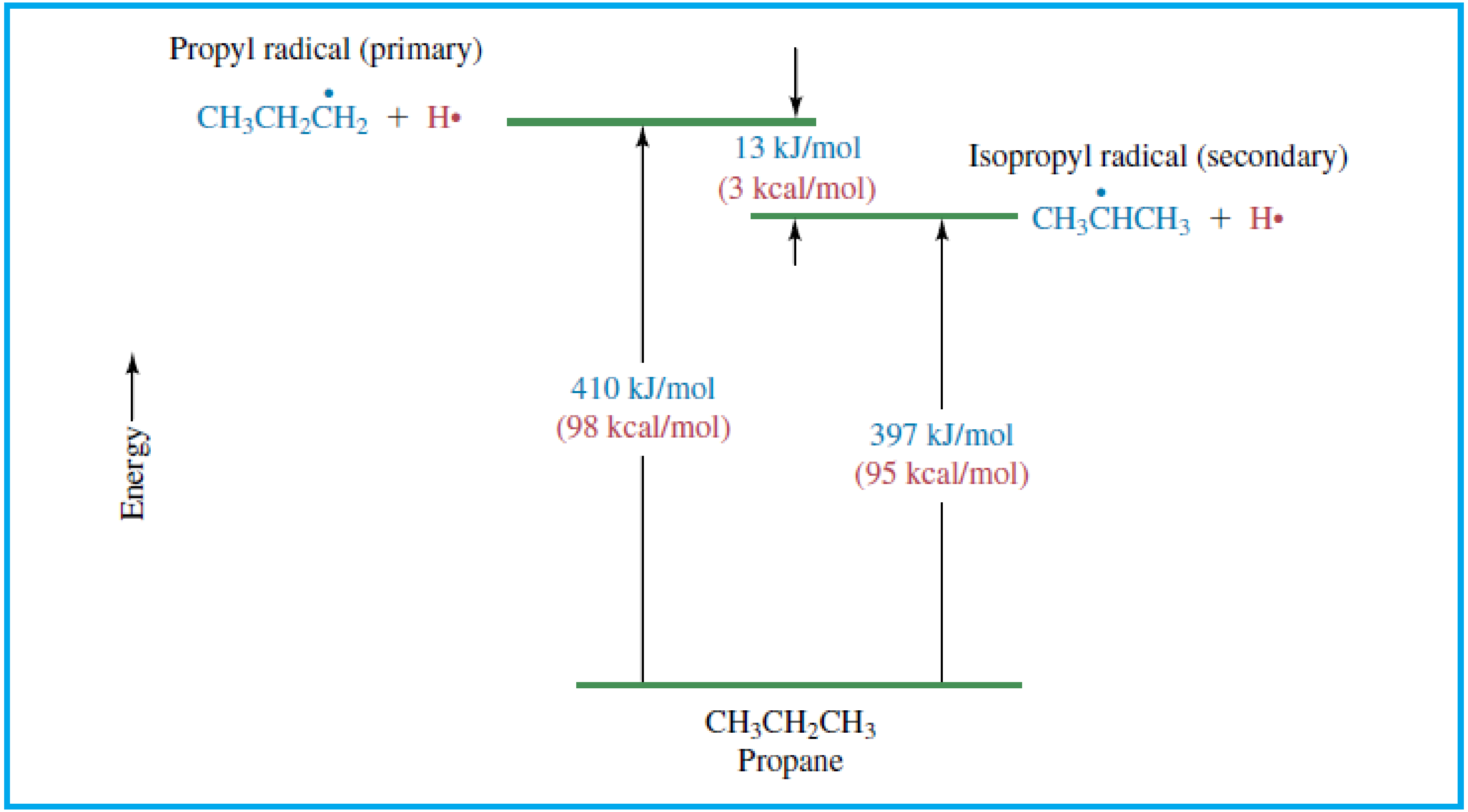


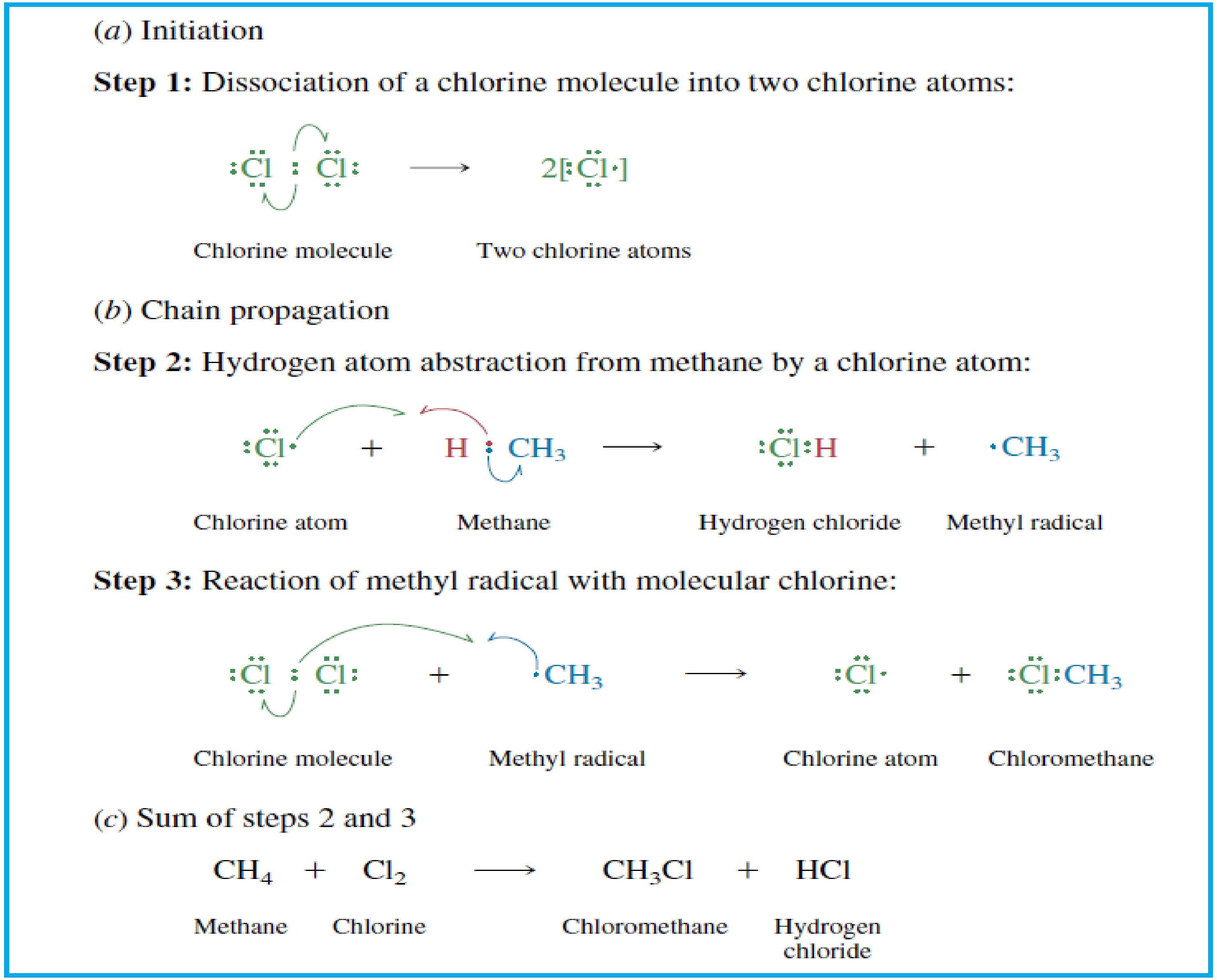
$CH_3\overset{\substack{H\\ |}}{\underset{\substack{|\\ CH_3}}{C}}CH_3 \longrightarrow CH_3\underset{\substack{|\\ CH_3}}{\dot{C}}CH_3 + H\cdot$ $\Delta H^\circ = +380$ kJ (91 kcal)

2-Methylpropane

tert-Butyl radical (tertiary)

Hydrogen atom


Propyl radical (primary)
$CH_3CH_2\dot{C}H_2$ + H•
13 kJ/mol
(3 kcal/mol)
Isopropyl radical (secondary)
$CH_3\dot{C}HCH_3$ + H•
410 kJ/mol
(98 kcal/mol)
397 kJ/mol
(95 kcal/mol)
Energy
$CH_3CH_2CH_3$
Propane



(*a*) Initiation

Step 1: Dissociation of a chlorine molecule into two chlorine atoms:

$$:\ddot{\underset{..}{Cl}}:\ddot{\underset{..}{Cl}}: \longrightarrow 2[:\ddot{\underset{..}{Cl}}\cdot]$$

Chlorine molecule — Two chlorine atoms

(*b*) Chain propagation

Step 2: Hydrogen atom abstraction from methane by a chlorine atom:

$$:\ddot{\underset{..}{Cl}}\cdot + H:CH_3 \longrightarrow :\ddot{\underset{..}{Cl}}:H + \cdot CH_3$$

Chlorine atom — Methane — Hydrogen chloride — Methyl radical

Step 3: Reaction of methyl radical with molecular chlorine:

$$:\ddot{\underset{..}{Cl}}:\ddot{\underset{..}{Cl}}: + \cdot CH_3 \longrightarrow :\ddot{\underset{..}{Cl}}\cdot + :\ddot{\underset{..}{Cl}}:CH_3$$

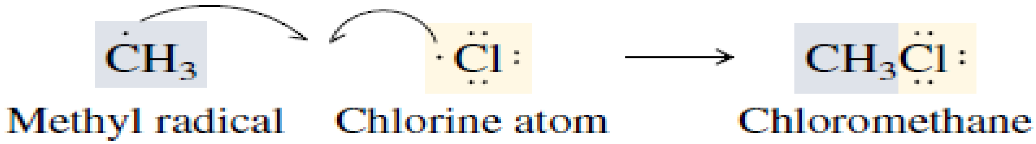
Chlorine molecule — Methyl radical — Chlorine atom — Chloromethane

(*c*) Sum of steps 2 and 3

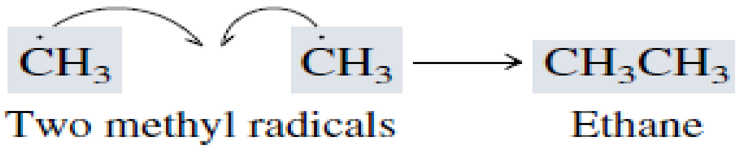
$$CH_4 + Cl_2 \longrightarrow CH_3Cl + HCl$$

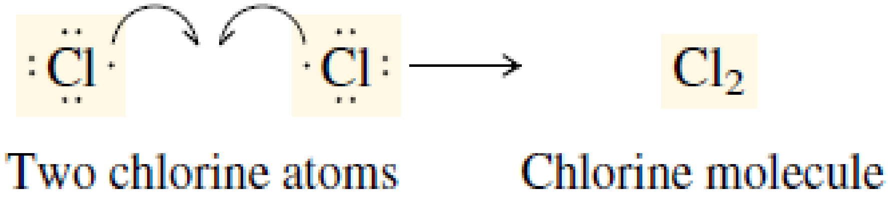
Methane — Chlorine — Chloromethane — Hydrogen chloride

Combination of a methyl radical with a chlorine atom:



Combination of two methyl radicals:





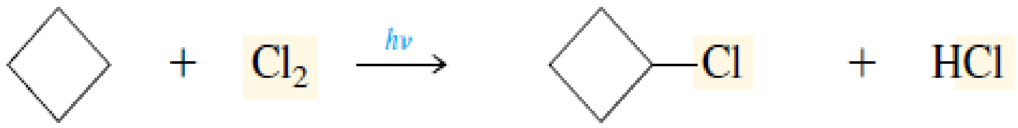
$$CH_3CH_3 + Cl_2 \xrightarrow{420^\circ C} CH_3CH_2Cl + HCl$$

Ethane

Chlorine

Chloromethane (78%)
(ethyl chloride)

Hydrogen chloride



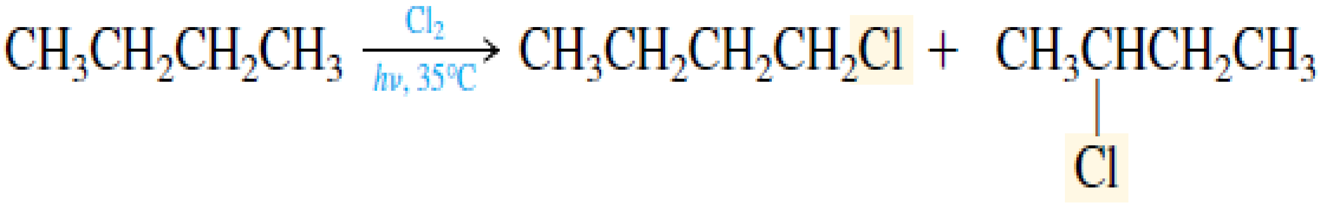
$$\text{Cyclobutane} + Cl_2 \xrightarrow{h\nu} \text{Chlorocyclobutane} + HCl$$

Cyclobutane

Chlorine

Chlorocyclobutane (73%)
(cyclobutyl chloride)

Hydrogen
chloride



$$CH_3CH_2CH_2CH_3 \xrightarrow[h\nu,\ 35^\circ C]{Cl_2} CH_3CH_2CH_2CH_2Cl + CH_3\underset{\underset{\textstyle Cl}{|}}{CH}CH_2CH_3$$

Butane

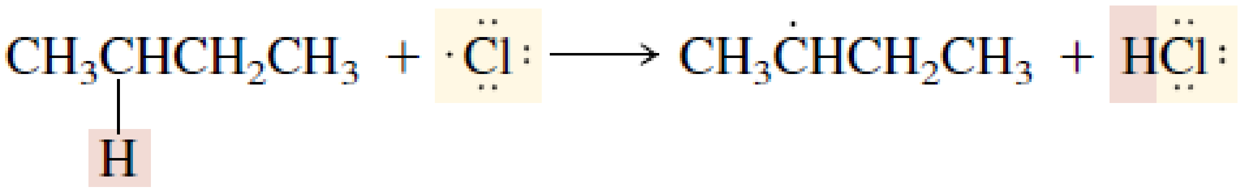
1-Chlorobutane (28%)
(*n*-butyl chloride)

2-Chlorobutane (72%)
(*sec*-butyl chloride)

$$CH_3CH_2CH_2CH_2{-}H + \cdot\ddot{\underset{\cdot\cdot}{\mathrm{Cl}}}\colon \longrightarrow CH_3CH_2CH_2\dot{C}H_2 + H\ddot{\underset{\cdot\cdot}{\mathrm{Cl}}}\colon$$

Butane

n-Butyl radical



$$\underset{\displaystyle H}{CH_3\underset{|}{C}HCH_2CH_3} + \cdot\ddot{\underset{\cdot\cdot}{\mathrm{Cl}}}\colon \longrightarrow CH_3\dot{C}HCH_2CH_3 + H\ddot{\underset{\cdot\cdot}{\mathrm{Cl}}}\colon$$

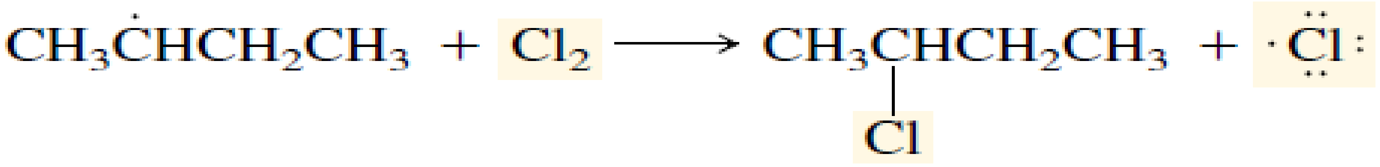
Butane

sec-Butyl radical

$$CH_3CH_2CH_2\dot{C}H_2 + Cl_2 \longrightarrow CH_3CH_2CH_2CH_2Cl + \cdot\ddot{\underset{\cdot\cdot}{\mathrm{Cl}}}\colon$$

n-Butyl radical

1-Chlorobutane
(*n*-butyl chloride)



$$CH_3\dot{C}HCH_2CH_3 + Cl_2 \longrightarrow CH_3\underset{\underset{\displaystyle Cl}{|}}{C}HCH_2CH_3 + \cdot\ddot{\underset{\cdot\cdot}{\mathrm{Cl}}}\colon$$

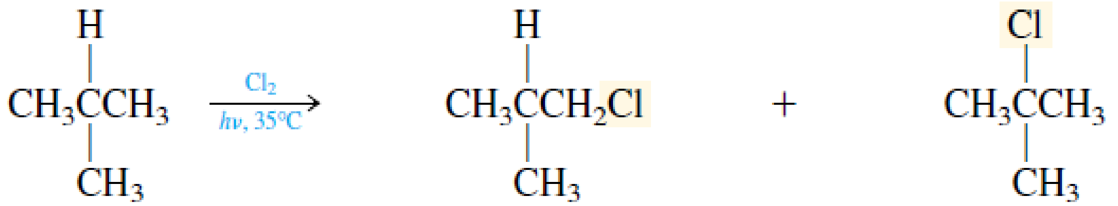
sec-Butyl radical

2-Chlorobutane
(*sec*-butyl chloride)

$$\frac{72\%\ \text{2-chlorobutane}}{28\%\ \text{1-chlorobutane}} = \frac{\text{rate of secondary H abstraction} \times 4\ \text{secondary hydrogens}}{\text{rate of primary H abstraction} \times 6\ \text{primary hydrogens}}$$

$$\frac{\text{Rate of secondary H abstraction}}{\text{Rate of primary H abstraction}} = \frac{72}{28} \times \frac{6}{4} = \frac{3.9}{1}$$

The selectivity of Bromination is more than chlorination:



$$CH_3\overset{\displaystyle H}{\underset{\displaystyle CH_3}{C}}CH_3 \xrightarrow[h\nu,\ 35°C]{Cl_2} CH_3\overset{\displaystyle H}{\underset{\displaystyle CH_3}{C}}CH_2Cl + CH_3\overset{\displaystyle Cl}{\underset{\displaystyle CH_3}{C}}CH_3$$

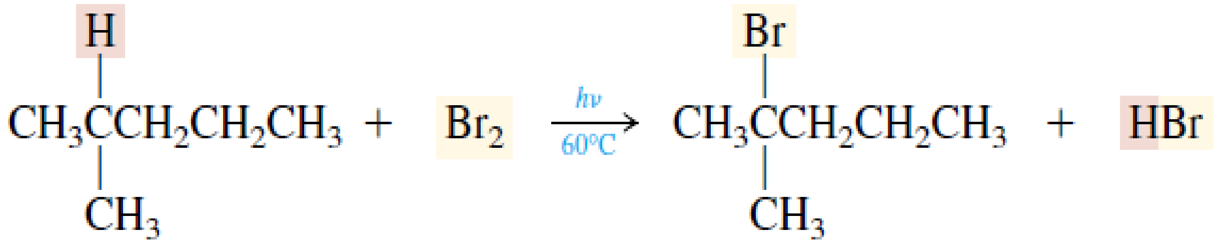
2-Methylpropane

1-Chloro-2-methylpropane (63%) (isobutyl chloride)

2-Chloro-2-methylpropane (37%) (*tert*-butyl chloride)

	R_3CH >	R_2CH_2 >	RCH_3
	(tertiary)	(secondary)	(primary)
Relative rate (chlorination)	5.2	3.9	1

	R_3CH >	R_2CH_2 >	RCH_3
	(tertiary)	(secondary)	(primary)
Relative rate (bromination)	1640	82	1



$$CH_3\overset{\displaystyle H}{\underset{\displaystyle CH_3}{C}}CH_2CH_2CH_3 + Br_2 \xrightarrow[60°C]{h\nu} CH_3\overset{\displaystyle Br}{\underset{\displaystyle CH_3}{C}}CH_2CH_2CH_3 + HBr$$

2-Methylpentane

Bromine

2-Bromo-2-methylpentane (76% isolated yield)

Hydrogen bromide