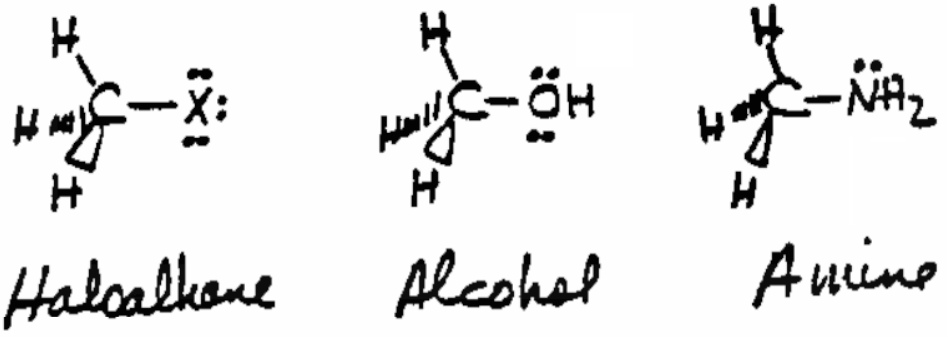
3.1. Simplest Haloalkane, Alcohol and Amine



3.2. C-X, C-O, and C-N Bonds are Polar

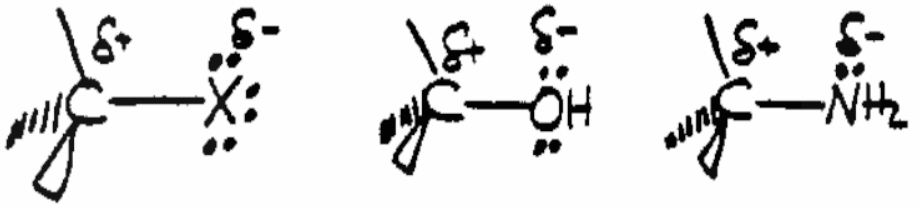
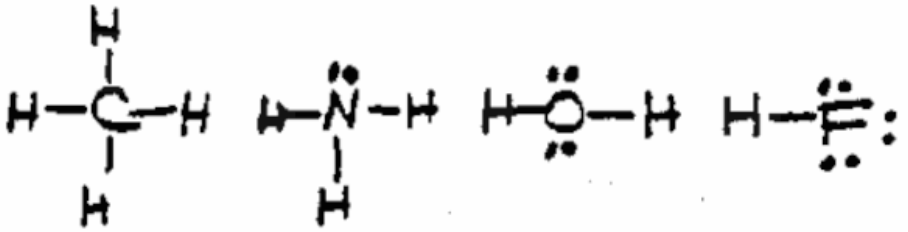


Figure [graphic 3.3]. A partial periodic table showing the first 10 elements, the remaining halogens, their preferred number of chemical bonds, and number of valence shell unshared electron pairs in their neutral compounds.

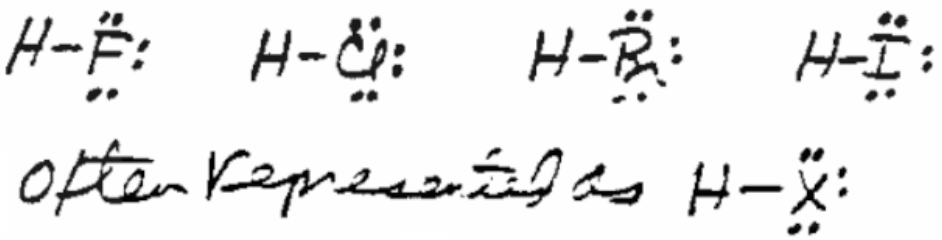
	H 1							He 2
	Li 3	Be 4	B 5	**C** 6	**N** 7	**O** 8	**F** 9 **Cl** 17 **Br** 35 **I** 53	Ne 10
Bonds	1	2	3	4	3	2	1	0
Unshared e pairs	0	0	0	0	1	2	3	4

3.4



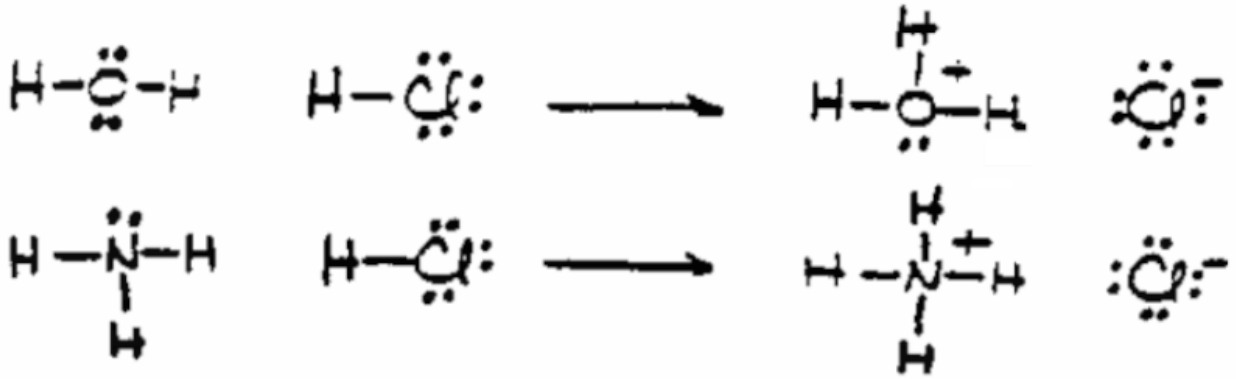
	CH_4	NH_3	H_2O	HF
Bonds	4	3	2	1
Unshared electron pairs	0	1	2	3

3.5. Halogen Atoms have Three Unshared Electron Pairs

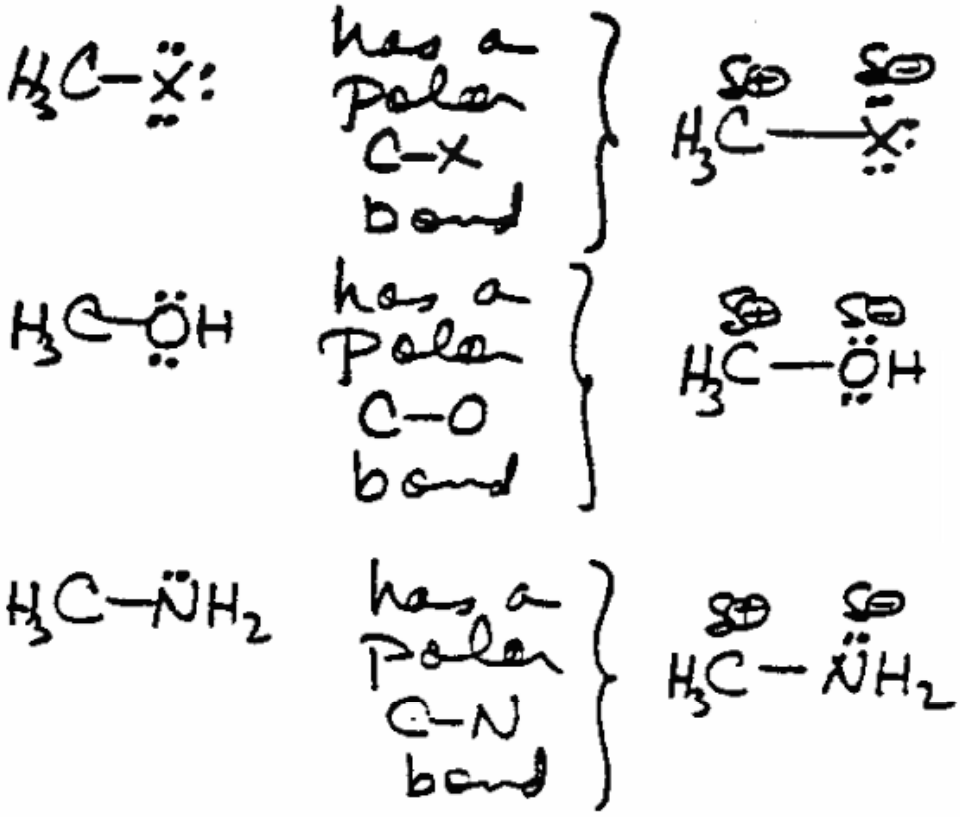


often represented as

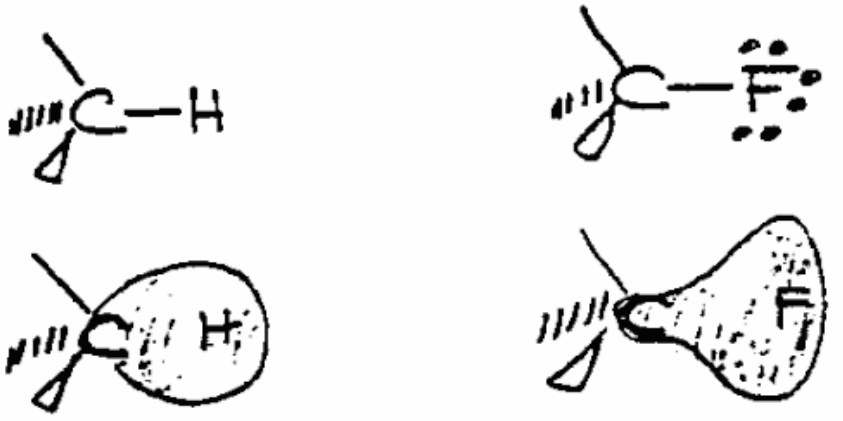
3.6



3.7. Neutral Molecules with Polar Bonds



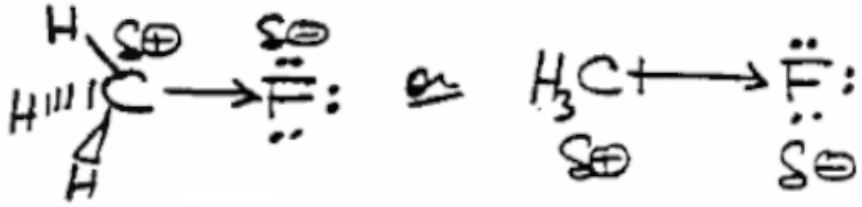
3.8. "Electron Cloud" Pictures of Chemical Bonds



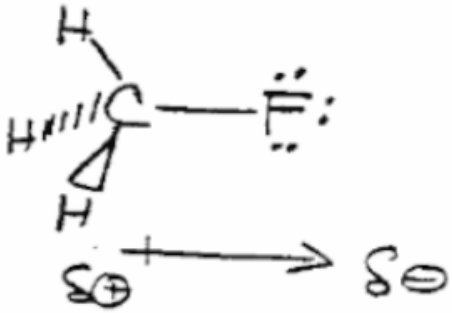
H 2.3						
Li 1.0	Be 1.5	B 2.0	C 2.5	N 2.9	O 3.4	F 3.9
Na 0.9	Mg 1.4	Al 1.8	Si 2.3	P 2.3	S 2.7	Cl 3.1
						Br 3.0
						I 2.7

Figure [graphic 3.9] . Electronegativity values for selected elements in the periodic table. These are Mulliken values converted to the Pauling scale (Bratsch, S. G. *J. Chem. Ed.* **1988**, *65*, 34, and 223)

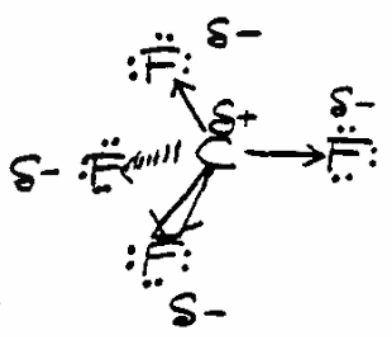
3.10. C-F Bond Dipoles



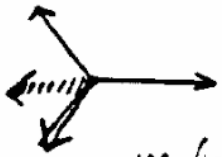
3.11. Molecular Dipole in CH_3F



3.12



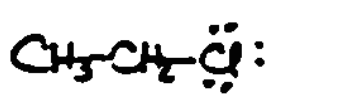
Bond These Dipoles Cancel Each Other



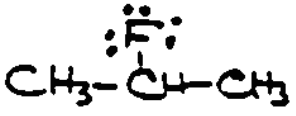
The Net Molecular Dipole Moment is Zero

3.13

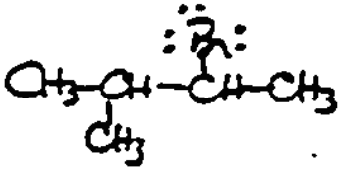
Chloromethane



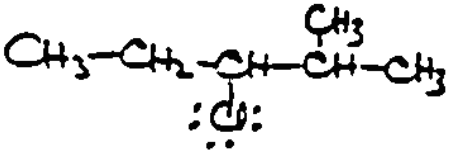
Chloroethane



2-Fluoropropene



2-Bromo-3-Methylbutene



3-Chloro-2-methylpentene

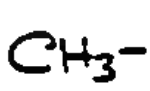
Iodocyclohexene

1-Ethyl-1-Iodocyclohexene

Cis-1-Bromo-2-Chlorocyclopentane

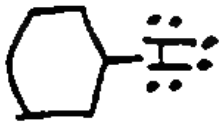
3.14. Common Names of Simple Haloalkanes

Chloromethane



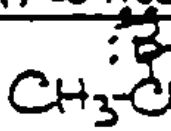
(Methyl Chloride)

Iodocyclohexane



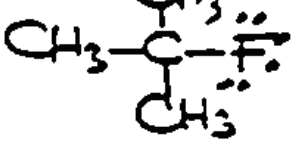
(Cyclohexyl iodide)

2-Bromopropane



(Isopropyl bromide)

2-Fluoro-2-Methyl-Propane



(t-Butyl fluoride)

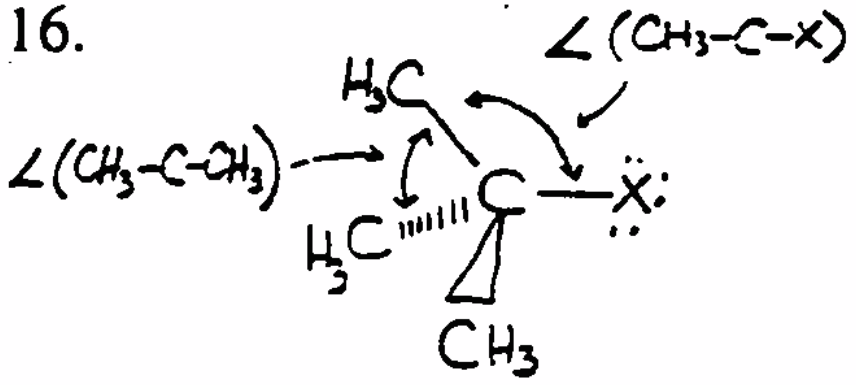
3.15. Common Names of Polychloromethanes

CH_2Cl_2 Dichloromethane or Methylene Chloride

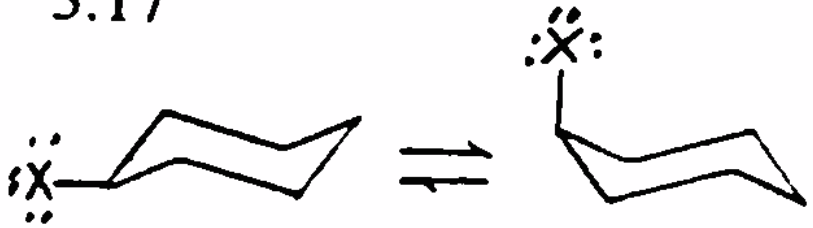
$CHCl_3$ Trichloromethane or Chloroform

CCl_4 Tetrachloromethane or Carbon Tetrachloride

3.16.



3.17

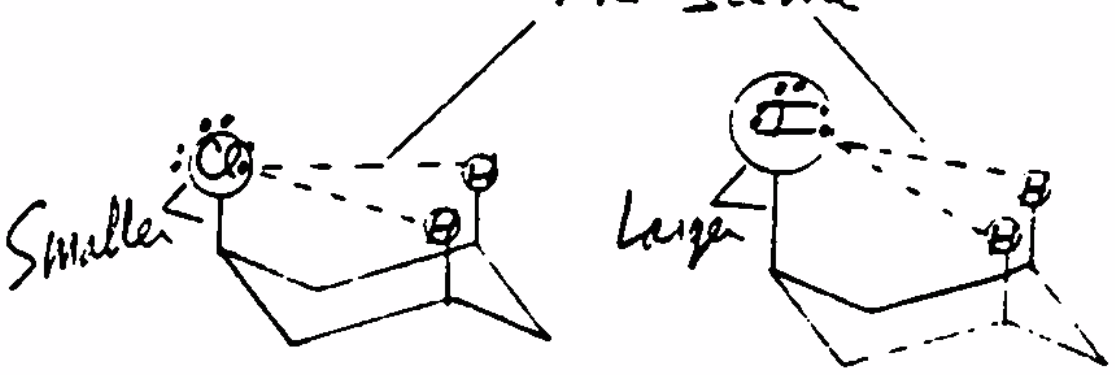


Equatorial X
More Stable

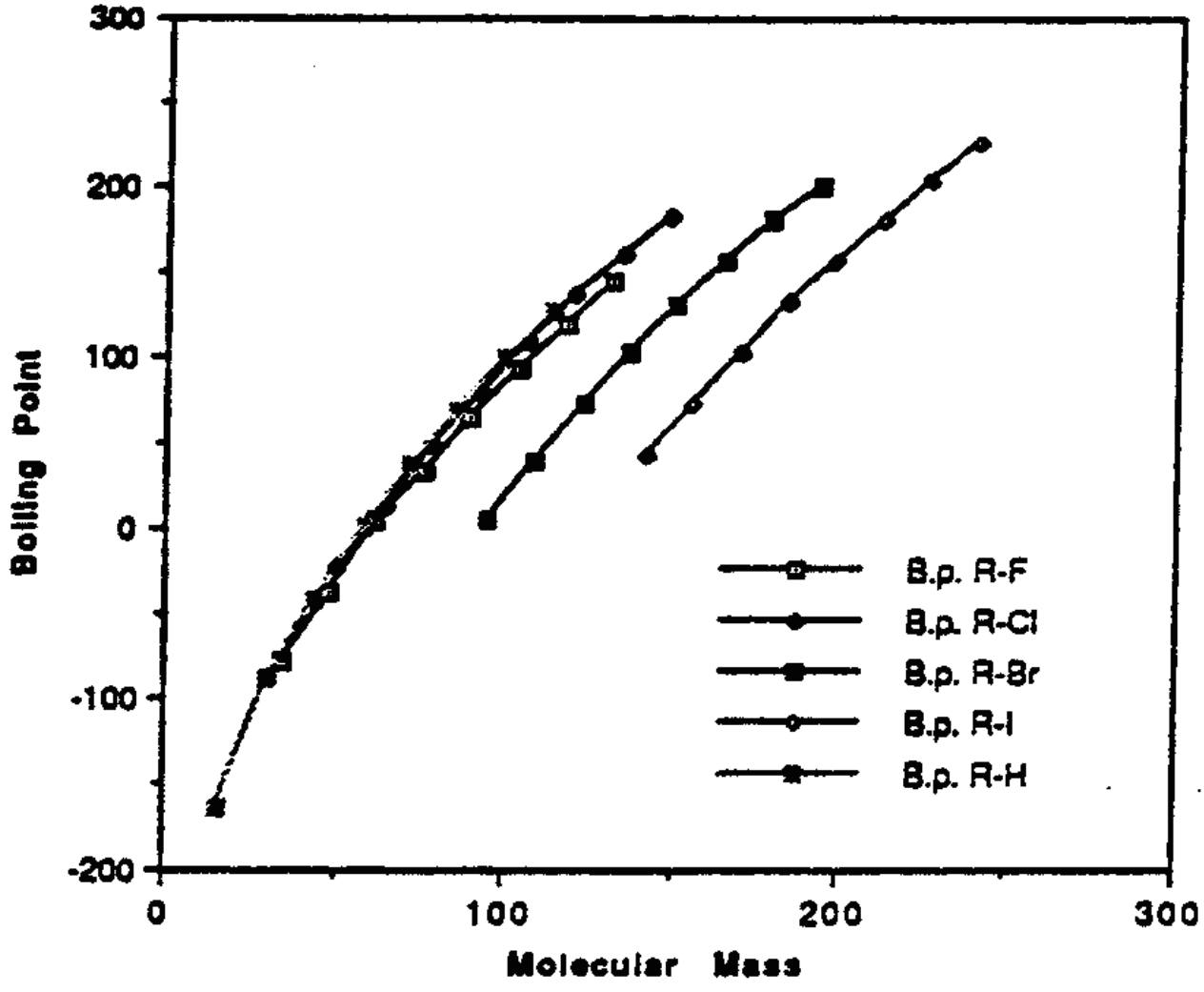
Axial X
less Stable

3.18

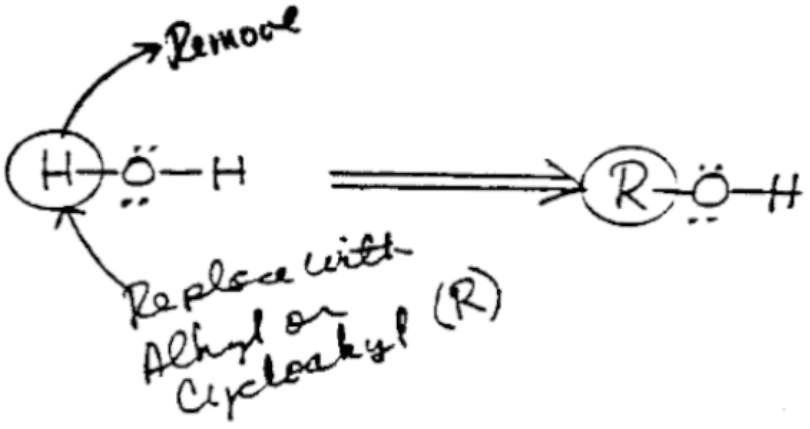
Separate. About The Same



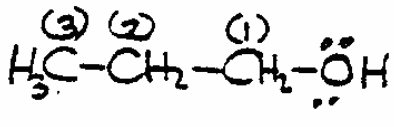
3.19 **Boiling Points of R-X and R-H**



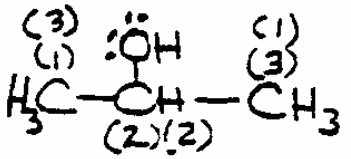
3.20



3.21

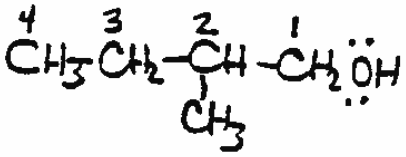


1-propanol

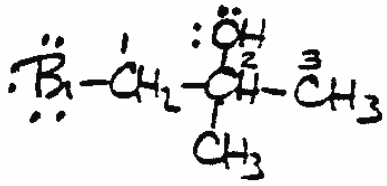


2-propanol

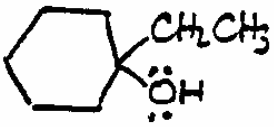
3.22



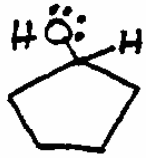
2-methyl-1-butanol



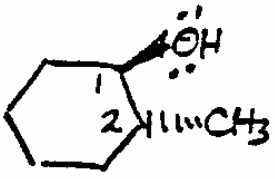
1-bromo-2-methyl-2-propanol



1-ethyl-1-cyclohexanol



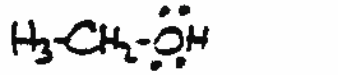
Cyclopentanol



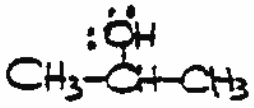
trans-2-methylcyclohexanol

3.23

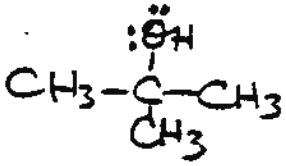
Methanol
or
methyl alcohol



ethanol
or
ethyl alcohol



2-propanol
or
isopropyl alcohol



2-methyl-2-propanol
or
t-butyl alcohol

3.25

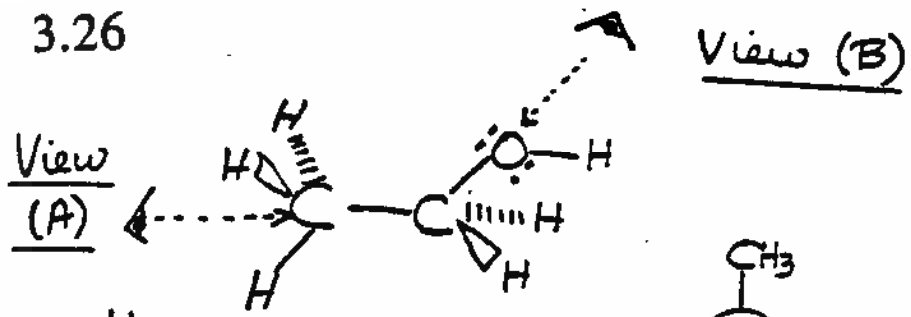
~105°

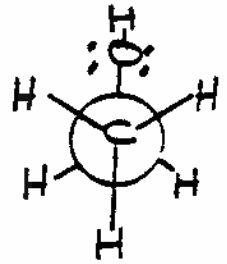
H_2O

~110°

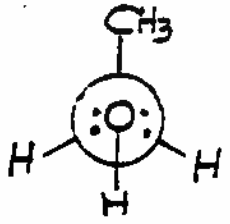
R-OH

3.26



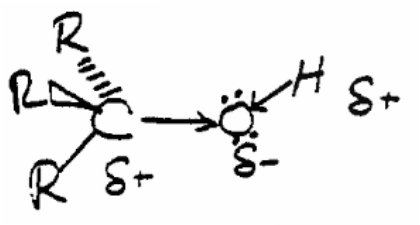


(A)

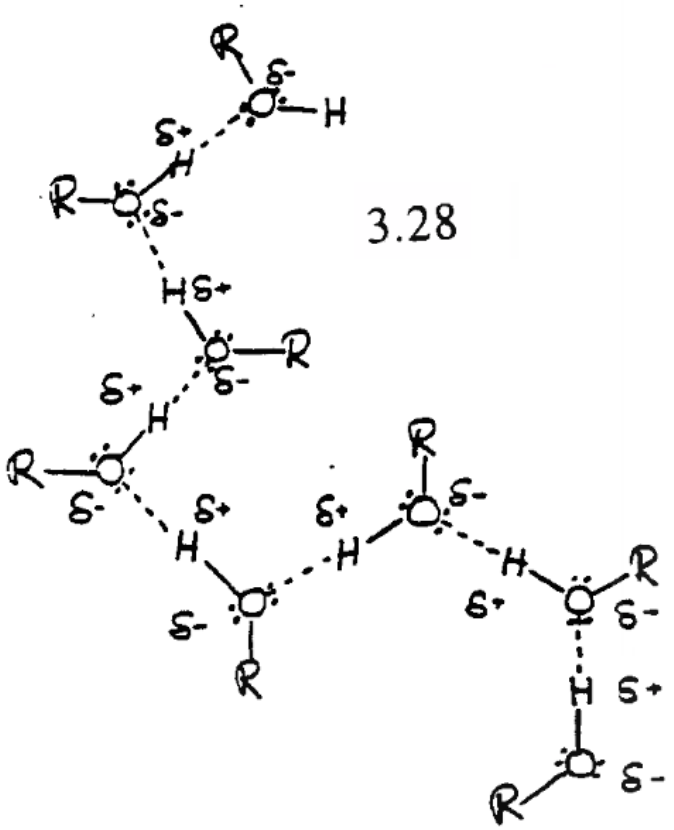


(B)

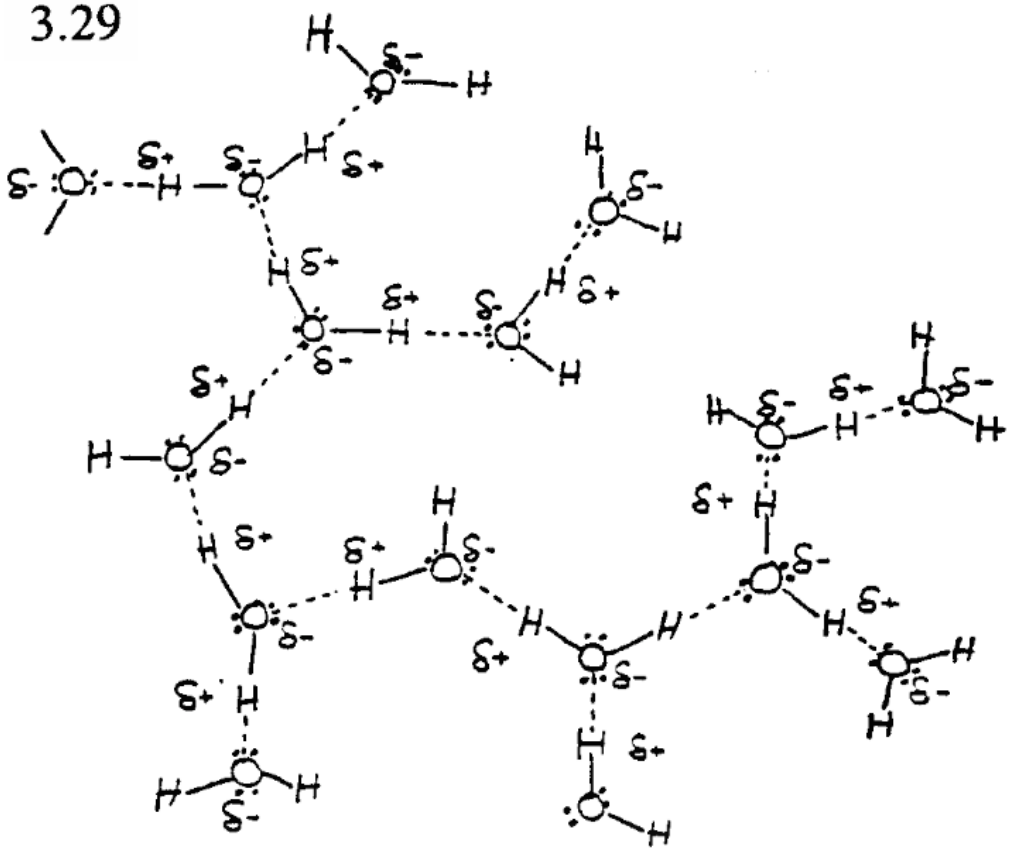
3.27



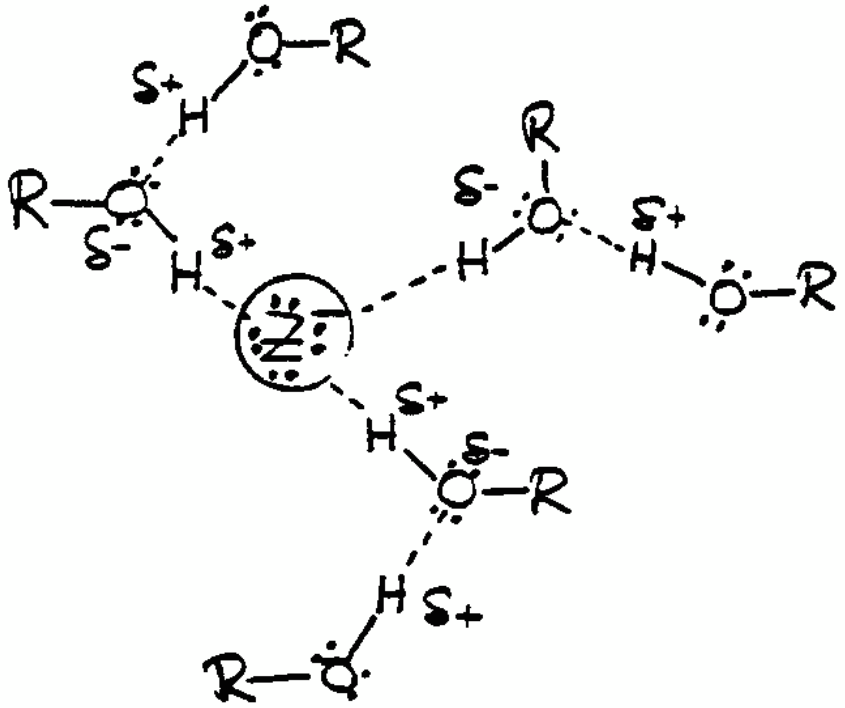
3.28



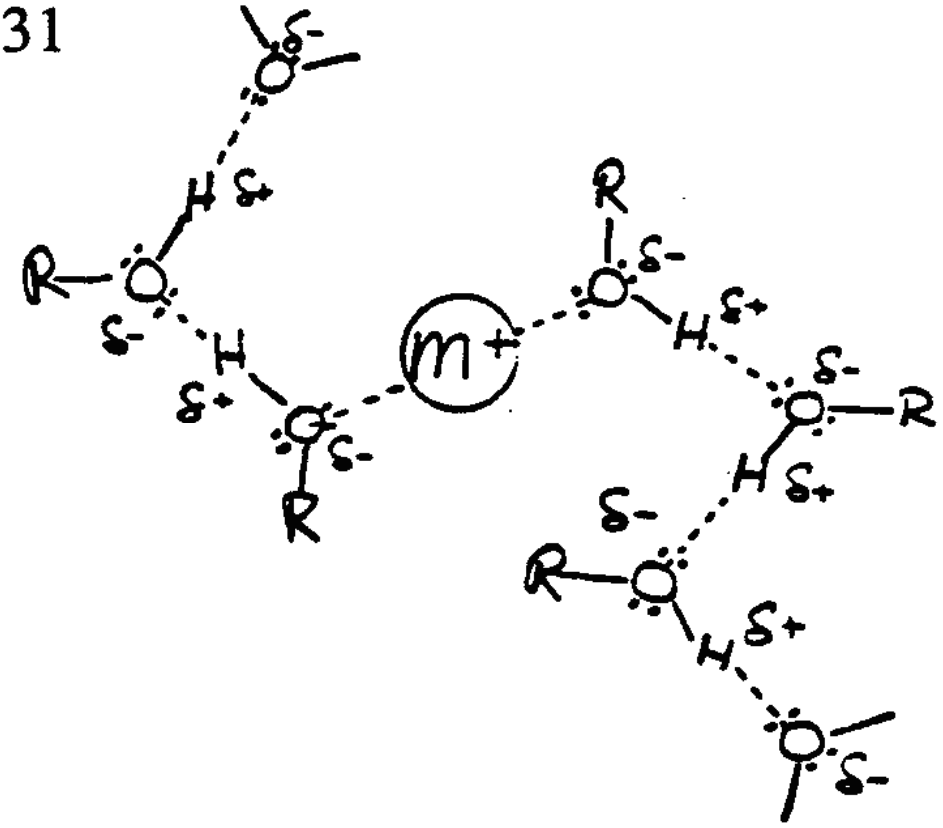
3.29



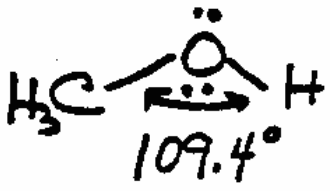
3.30

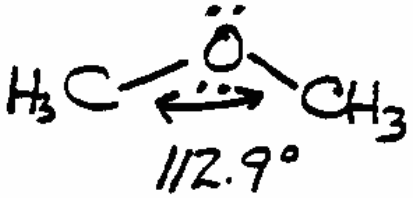


3.31



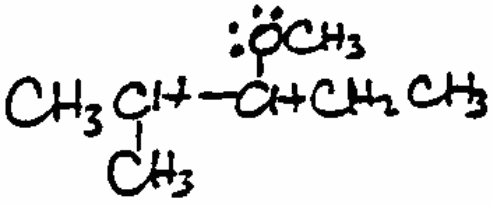
3.32



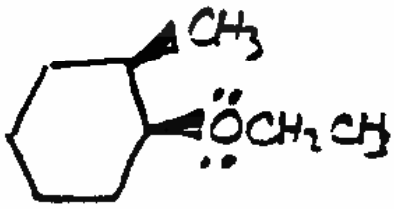


$CH_3\ddot{O}H$ $CH_3-\ddot{O}-CH_3$

3.33



3-methoxy-2-methylpentane



cis-1-ethoxy-2-methyl-cyclohexane

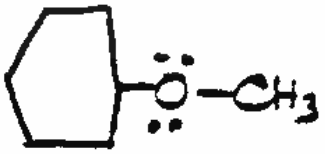
3.34

$CH_3CH_2-\ddot{O}-CH_2CH_3$

ethoxyethane

or

diethyl ether

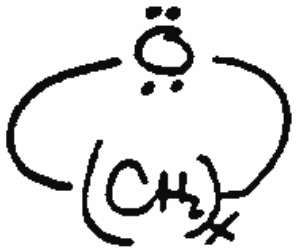


methoxycyclohexane

or

Cyclohexyl methyl ether

3.35



Cyclic Ether

"Oxacycloalkane"

3.36

Oxacyclopropane

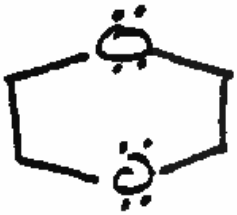
or

ethylene oxide

Oxacyclopentane

or

tetrahydrofuran

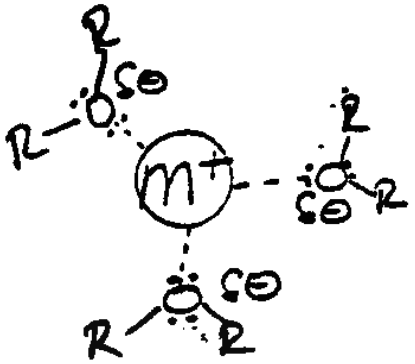


1,4-dioxacyclohexane

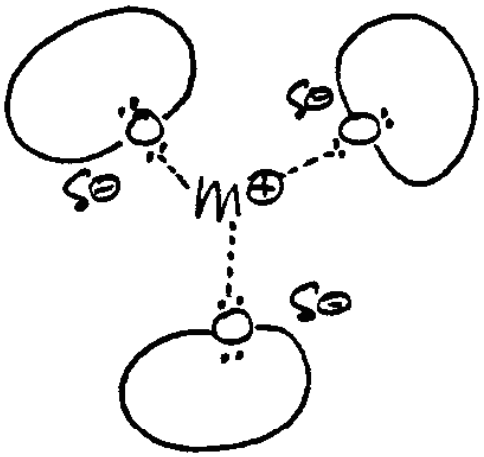
or

dioxane

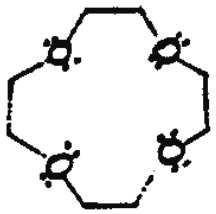
3.37



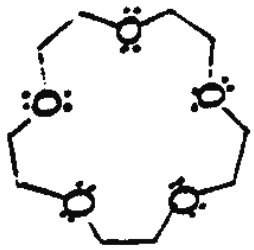
3.38



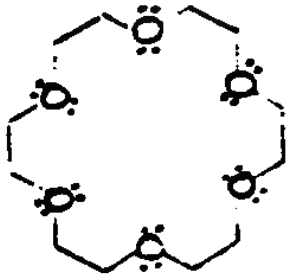
3.39



12-Crown-4

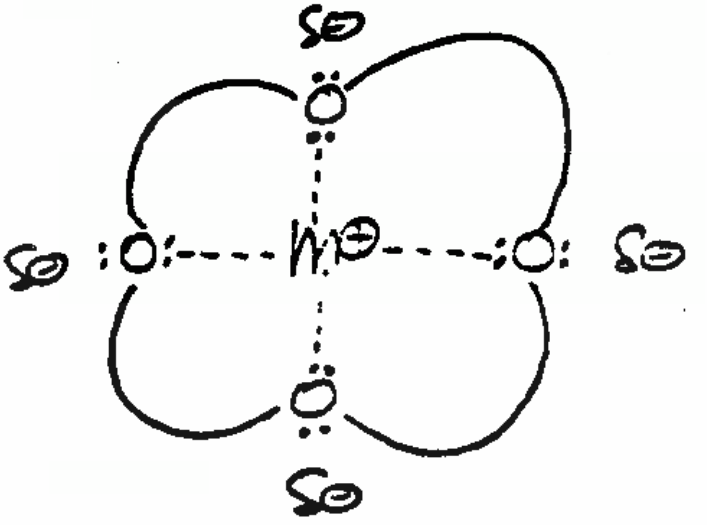


15-Crown-5

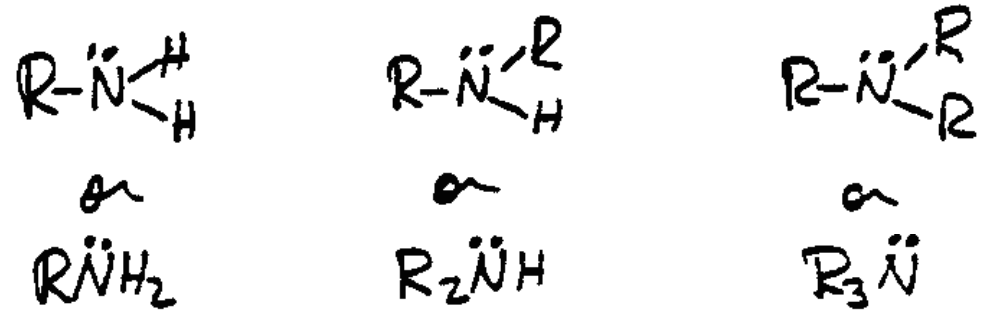


18-Crown-6

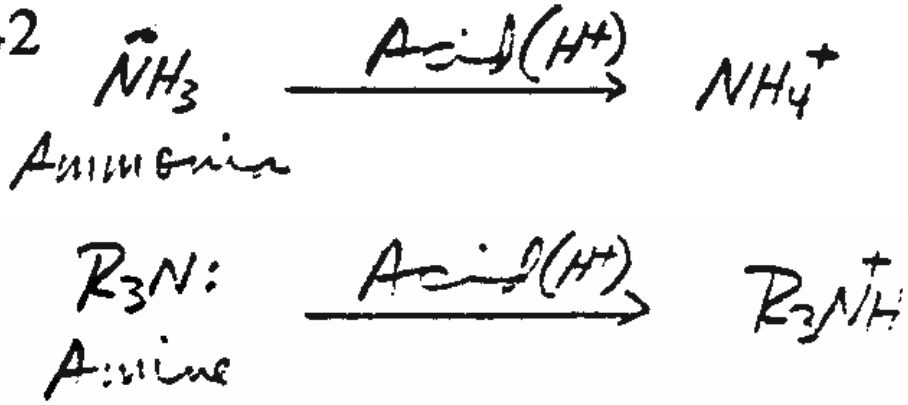
3.40



3.41

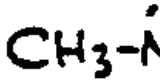

or
or
or
Primary (1°) Amine
Secondary (2°) Amine
Tertiary (3°) Amine

3.42


Acid (H+)
Acid (H+)
Ammonia
Amine

3.43

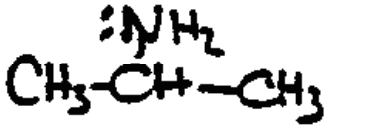
Some Amines and Their Names



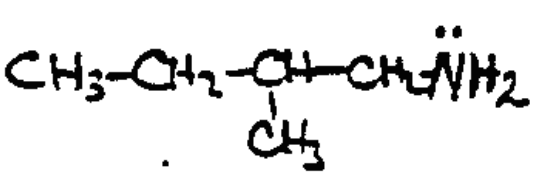
methanamine

ethanamine

1-propanamine



2-propanamine

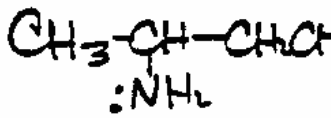


2-Methyl-1-butanamine

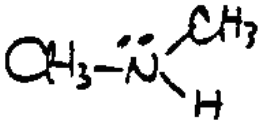
1-methylcyclohexan-amine

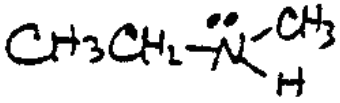
3.44 1° Amines


1-Propanamine
(propyl amine)

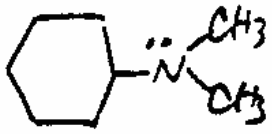

2-butanamine

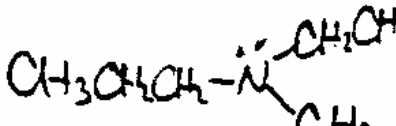
2° Amines


N-Methylmethanamine
(dimethylamine)


N-methylethanamine
(ethylmethylamine)

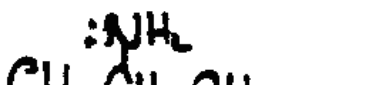
3° Amines


N,N-dimethylcyclohexanamine
(cyclohexyldimethylamine)

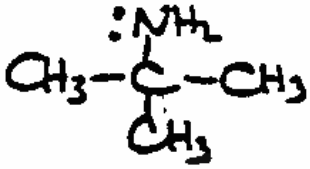

N-ethyl-N-Methyl-1-propanamine
(ethylmethylpropylamine)

3.44a

ethanamine
≡
ethylamine



2-propanamine
≡
isopropylamine



2-methylpropanamine
≡
t-butylamine

Cyclohexenamine
≡
Cyclohexylamine

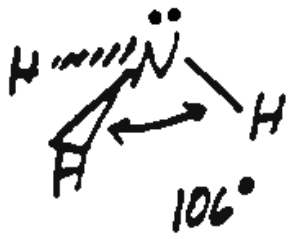
3.45

azacyclopentane
≡
Pyrrolidine

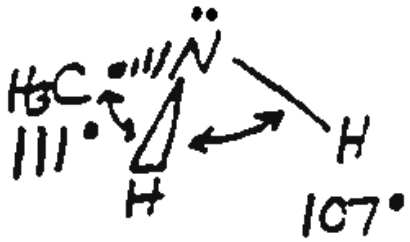
azacyclohexane
≡
Piperidine

N-MethylazaCyclohexane
≡
N-Methylpiperidine

3.46

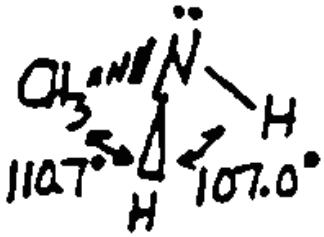


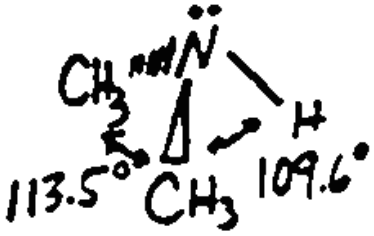
NH_3

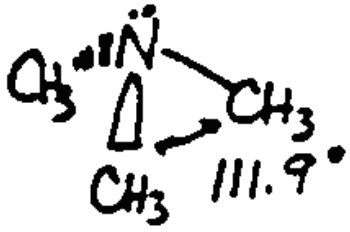


$R\text{-}NH_2$

3.47





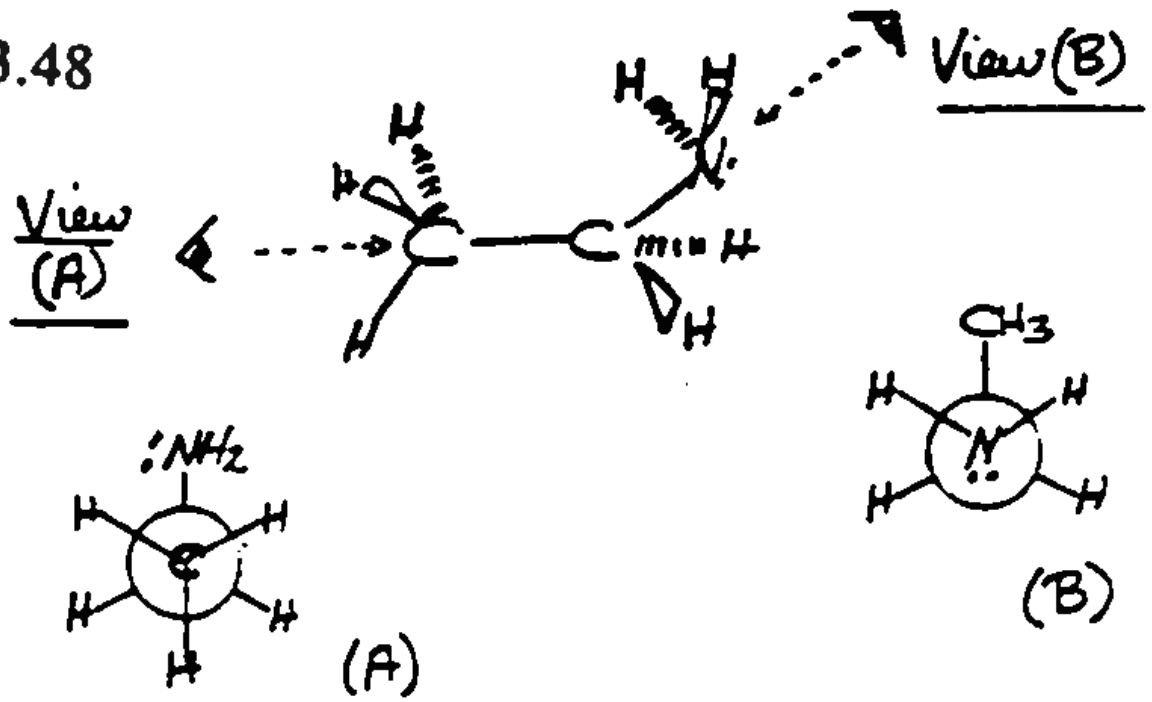


CH_3NH_2

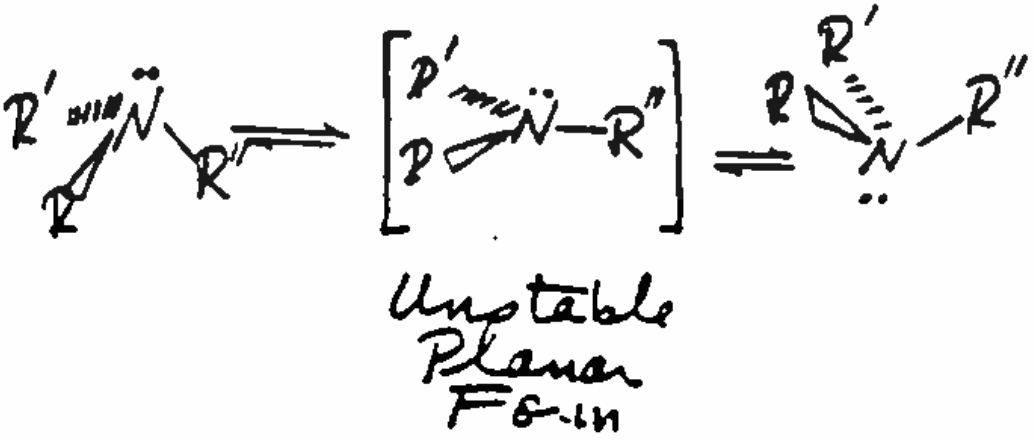
$(CH_3)_2NH$

$(CH_3)_3N$

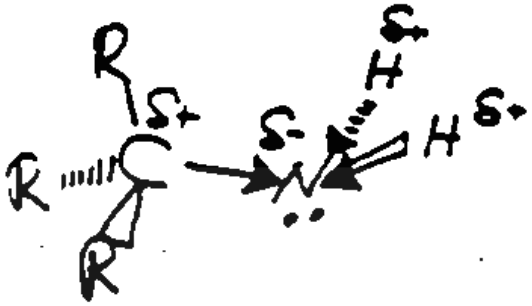
3.48



3.49

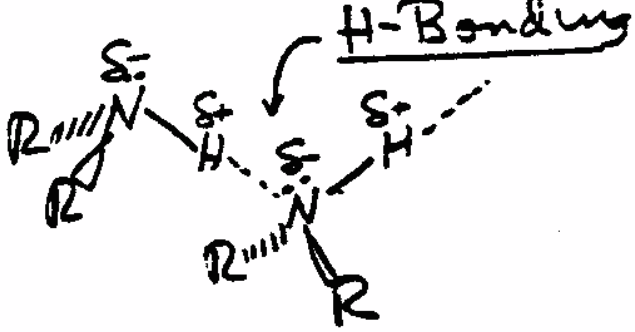


3.50

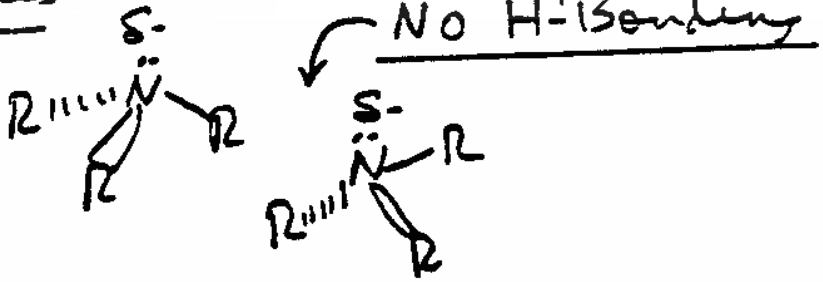


3.51

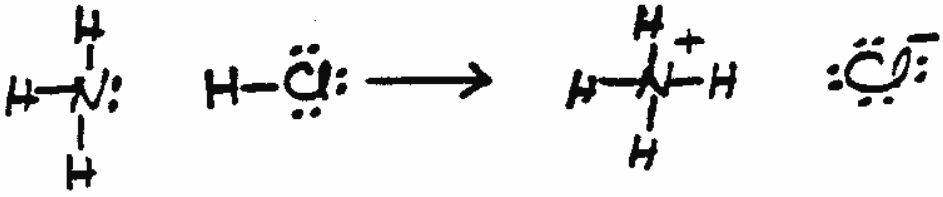
2° Amines



3° Amines



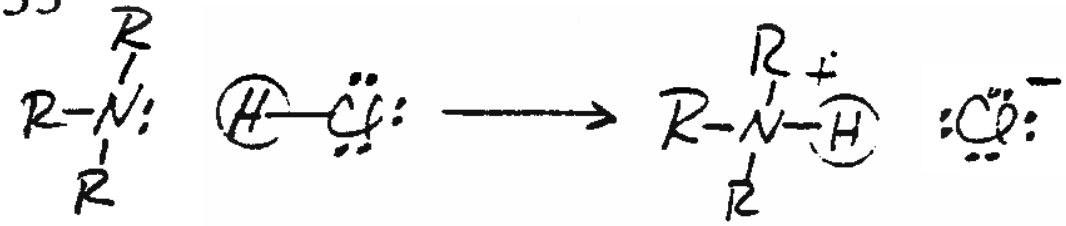
3.52



Ammonia

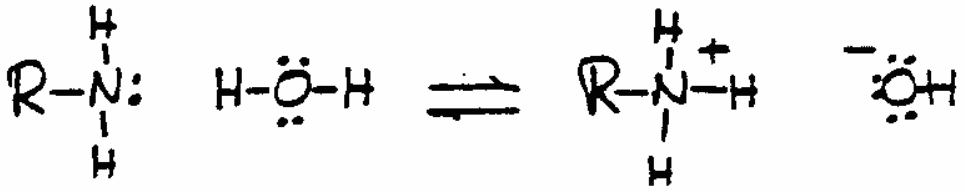
Ammonium Ion

3.53



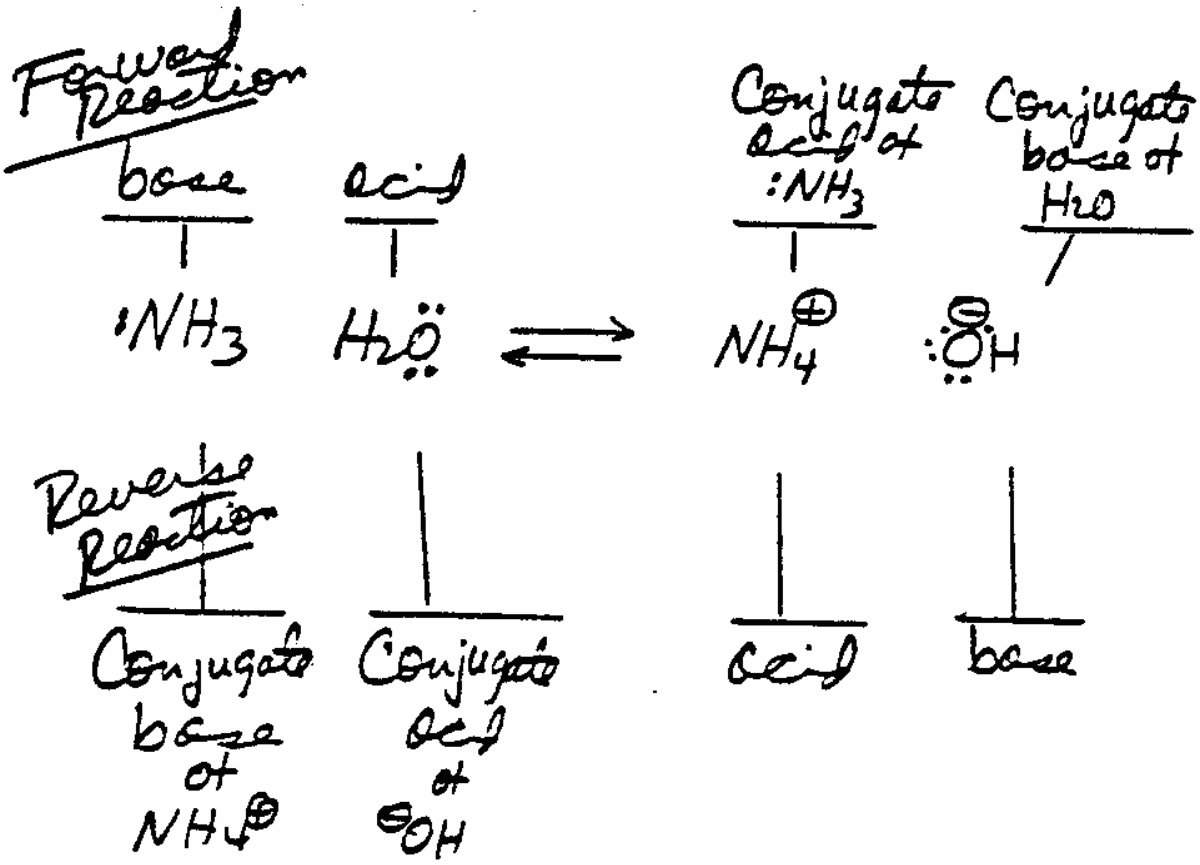
1°, 2°, or 3° Amine

Alkylammonium Ion

3.54 

3.55 

3.56


Forward Reaction
base
acid
Conjugate acid of :NH3
Conjugate base of H2O
:NH3
H2O
NH4⊕
:⊖OH
Reverse Reaction
Conjugate base of NH4⊕
Conjugate acid of ⊖OH
acid
base

3.57 $R-\ddot{N}H_2$ (base form) } In equilibrium in water { $R-NH_3^{\oplus}$ (acid form)

Increase in base strength of $R-NH_2$ shifts equilibrium towards $R-NH_3^{\oplus}$

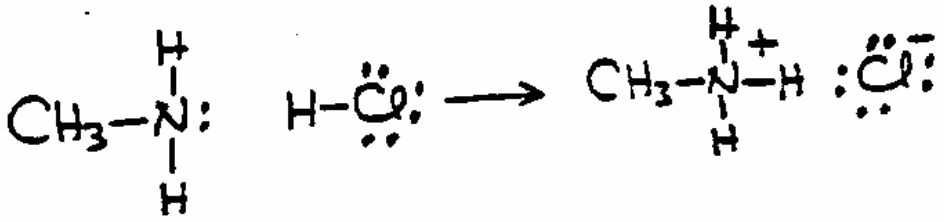
Result is $[R-NH_3^+]/[R-\ddot{N}H_2]$ increases

3.58 $R-\ddot{N}H_2$ (base form) } In equilibrium in water { $R-\overset{\oplus}{N}H_3$ (acid form)

Increase in acid strength of $R-NH_3^{\oplus}$ shifts equilibrium towards $R-NH_2$

Result is $[R-NH_3^+]/[R-\ddot{N}H_2]$ decreases

3.59

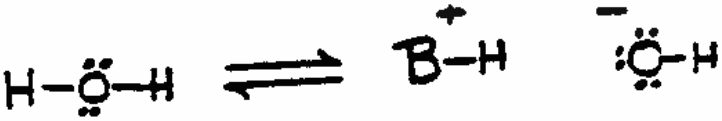


3.60

3.61

"Base" "Acid"

3.62



"Base" "Acid"

3.63

"Base" "Acid"

3.64 $CH_3\ddot{N}H_3^{\oplus} + H_2\ddot{O} \rightleftharpoons CH_3\ddot{N}H_2 + H_3\ddot{O}^{\oplus}$

$$K = \frac{[CH_3\ddot{N}H_2][H_3\ddot{O}^{\oplus}]}{[CH_3NH_3^+][H_2\ddot{O}]}$$

3.65 $H_2\ddot{O} + HA \rightleftharpoons H_3\ddot{O}^+ + A\!:^-$

$\Leftrightarrow$

$HA + H_2\ddot{O} \rightleftharpoons A\!:^- + H_3\ddot{O}^+$

$$K = \frac{[H_3\ddot{O}^+][A\!:^-]}{[H_2\ddot{O}][HA]}$$

3.66 $$K = \frac{[H_3\ddot{O}^+][A\!:^-]}{[H_2\ddot{O}][HA]}$$

$\Leftrightarrow$

$$K \cdot [H_2\ddot{O}] = \frac{[H_3\ddot{O}^+][A\!:^-]}{[HA]} \equiv K_a$$

3.67 $R\text{-}\overset{+}{N}H_3 + H_2\ddot{O} \rightleftharpoons R\text{-}\ddot{N}H_2 + H_3\ddot{O}^+$

$$K_a = \frac{[R\text{-}\ddot{N}H_2][H_3\ddot{O}^+]}{[R\text{-}NH_3^+]}$$

$$\Rightarrow$$

$$\frac{[R\text{-}\ddot{N}H_2]}{[R\text{-}NH_3^+]} = \frac{K_a}{[H_3\ddot{O}^+]}$$

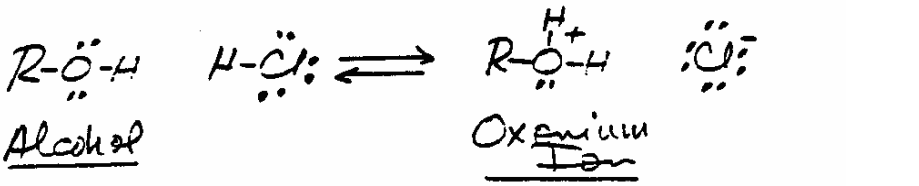
3.68 $\underset{\text{Form}}{\text{Acid}} + H_2\ddot{O} \rightleftharpoons \underset{\text{Form}}{\text{Base}} + H_3\ddot{O}^+$

$$K_a = \frac{[\text{Base Form}][H_3\ddot{O}^+]}{[\text{Acid Form}]}$$

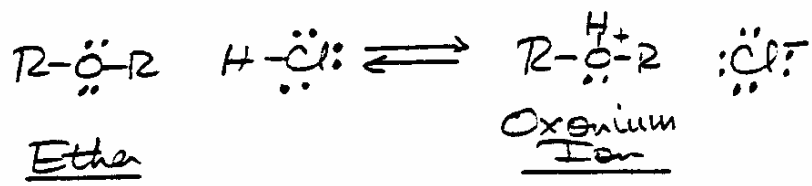
$$\Rightarrow$$

$$\frac{[\text{Base Form}]}{[\text{Acid Form}]} = \frac{K_a}{[H_3\ddot{O}^+]}$$

3.69

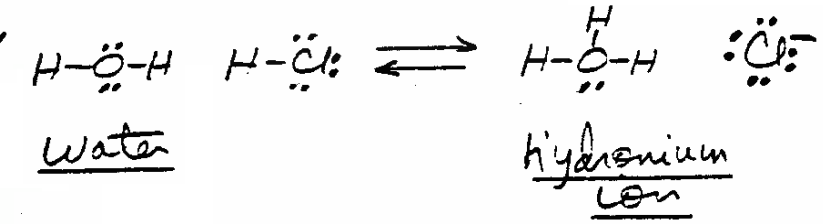


Alcohol — Oxonium Ion



Ether — Oxonium Ion

Analogous to:

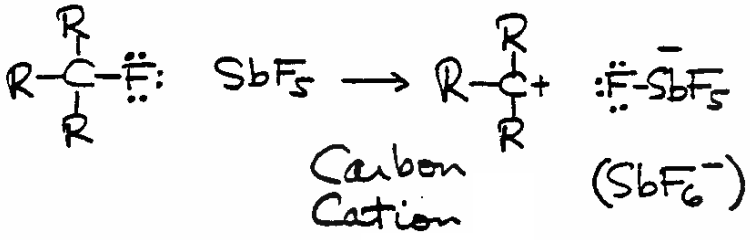


Water — Hydronium Ion

3.70

Oxonium Ion	Alcohol
$R-\ddot{O}H_2^{\oplus}$	$R-\ddot{O}H$
$K_a \simeq 10^{+2}$ / Strong Acid	Weaker Base than $R-\ddot{N}H_2$
Aminium Ion	Amine
$R-NH_3^{\oplus}$	$R-\ddot{N}H_2$
$K_a \simeq 10^{+11}$ / Weak Acid	Stronger Base than $R-\ddot{O}H$

3.71



Carbon Cation — (SbF_6^-)