Chapter 3 Nonaromatic Heterocycles

3.1 Bond angle strain

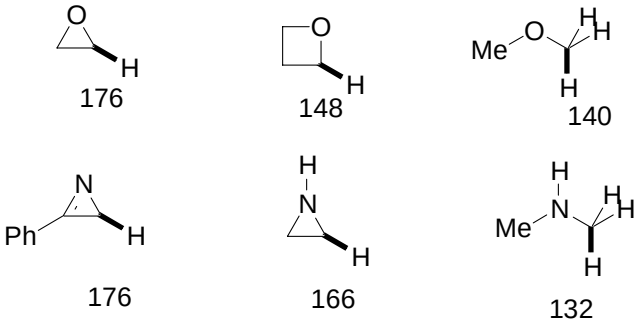
3.1.1 Angle strain and bonding in small-ring heterocycles

X	CXC (°)	C−C (Å)	C−X (Å)	Strain kcal mol^{-1} (kJ mol^{-1})
CH_2	60	1.510	1.510	27.5 (115)
NH	60	1.481	1.475	27.1 (113)
O	61	1.472	1.436	27.2 (114)
S	48.5	1.492	1.819	19.9 (83)

Dimensions of saturated three-membered rings and their strain energies.

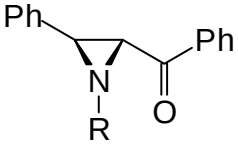
(a) (b)

Construction of bonding system of three-membered heterocycles (a) by interaction of ethylene π-orbital with unfilled orbital on X, (b) by interaction of π*-orbital with filled orbital on X.



^{13}C-H coupling constants (Hz) for some small-ring heterocycles and open-chain analogues.

3.1.2 Some consequences of bond angle strain in small rings



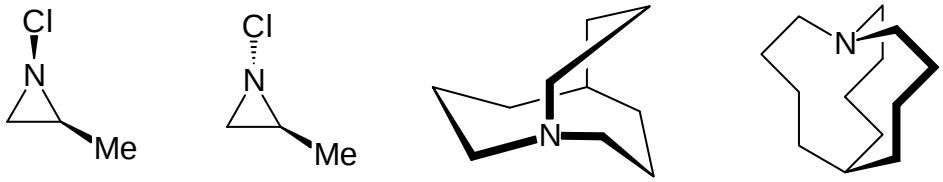
R = Me, UV 332.5 nm (*JACS*, **1945**, 2235)

Acetophenone λ_{max} 245.5 nm

Nitrogen inversion in aziridines

Influence of nitrogen substituents on barriers to nitrogen inversion in aziridines

R	$\Delta G^{\ddagger}$ [kcal mol^{-1} (kJ mol^{-1})]	T (^{o}C)
H	17.3 (72)	68
Et	19.4 (81)	108
CMe_3	17.0 (71)	52
Ph	11.7 (49)	-40
SO_2Me	12.8 (53.5)	-25
$CONMe_2$	9.9 (41)	-86
CO_2Me	7.1 (30)	-138
NH_2	>22 (>90)	150
Cl	>21 (>90)	120
OMe	>22 (>90)	130

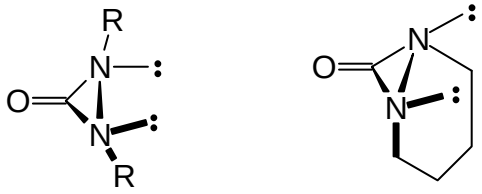


3.2 Tortional energy barriers

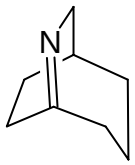
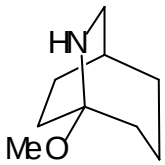
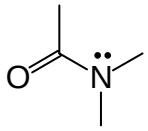
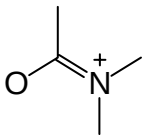
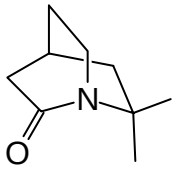
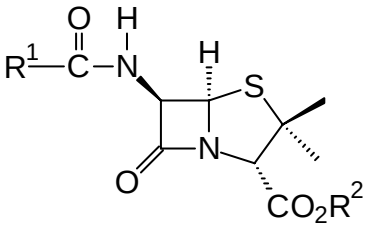
3.2.1 Single bonds

Rotational energy barriers for single bonds

Compound	Rotational barrier [kcal mol^{-1} (kJ mol^{-1})]
CH_3-CH_3	2.9 (12.2)
CH_3-NH_2	2.0 (8.3)
CH_3-OH	1.1 (4.6)
CH_3-SH	1.3 (5.3)



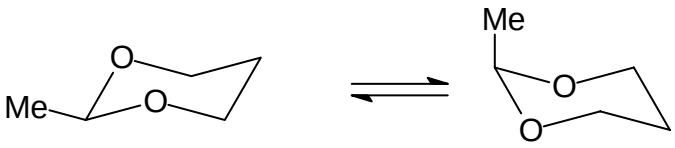
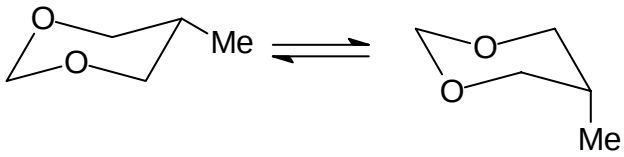
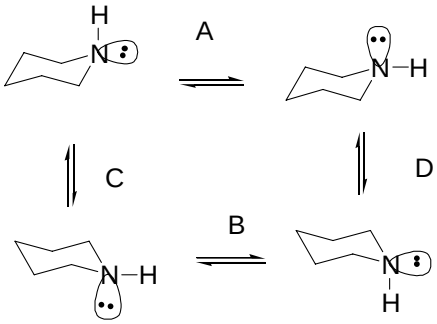
3.2.2 Double bonds and partial double bonds

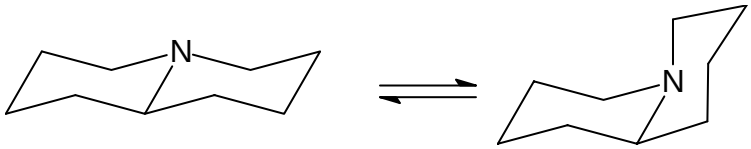







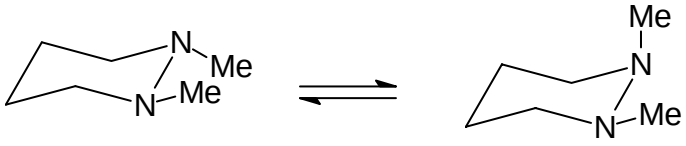
3.3 Influence of bond lengths and van der Waals radii: conformational preferences of flexible heterocycles

3.3.1 Saturated six-membered heterocycles

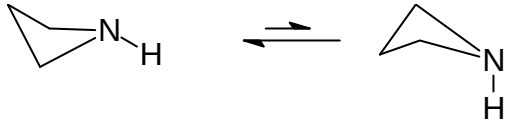
Barriers to ring inversion in six-membered heterocycles

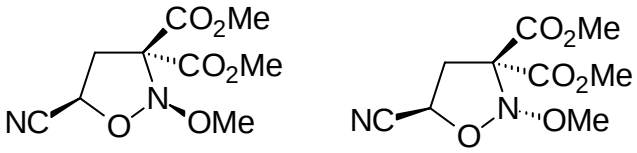








3.3.2 Four- and five-membered heterocycles

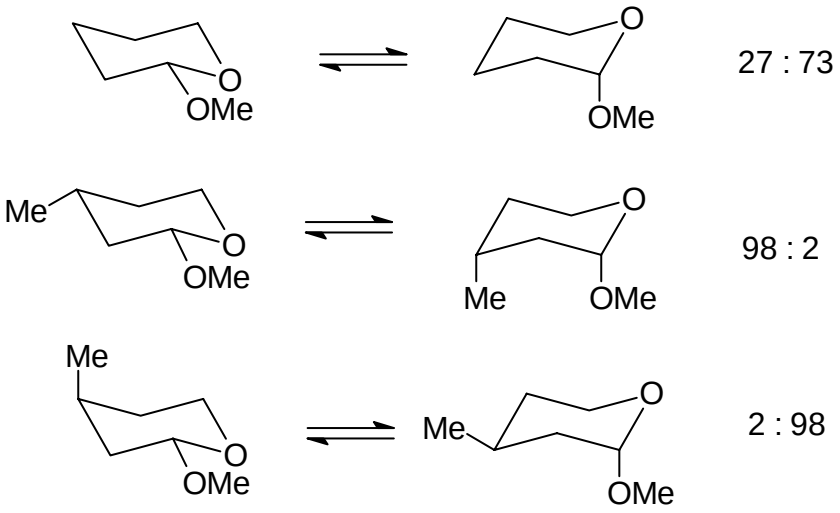




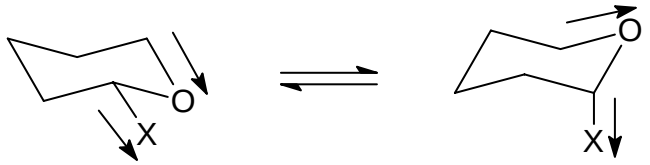
3.3 Other types of interaction in saturated heterocycles

Anomeric effect (in cyclohexane) for 2-substituents in tetrahydropyranes

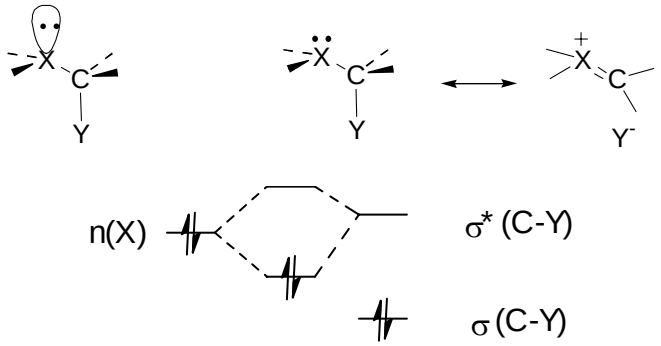
2-Substituent	Anomeric effect [kca mol-1 (kJ mol-1)]
Cl	2.4 (10.0)
Br	2.3 (9.6)
OMe	1.7 (7.1)
SMe	1.5 (6.3)
OH	0.8 (3.3)
NHMe	0.4 (1.7)



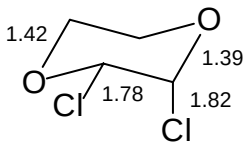
The anomeric effect (in benzene) for 2-methoxytetrahydropyran and the influence of a 4-methyl substituent on the position of equilibrium



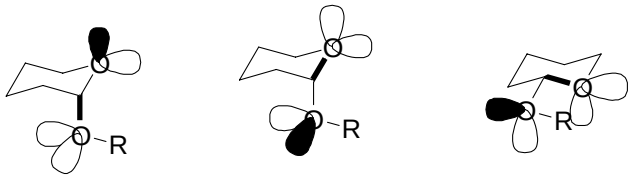
Aligment of dipoles in equatorial and axial conformations of tetrahydropyran bearing an electronegative 2-substituent



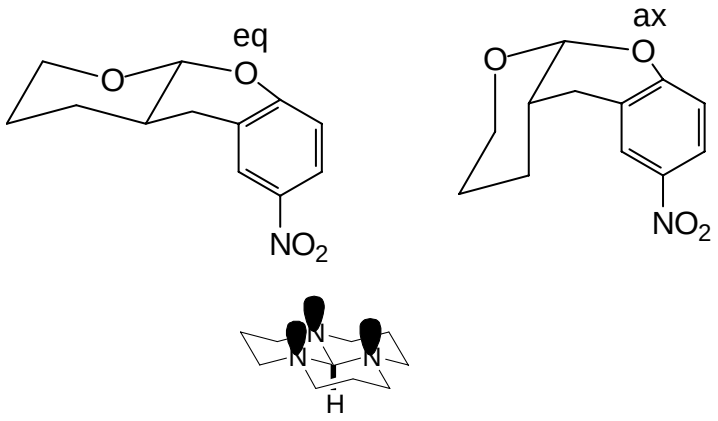
Antiperiplanar interaction of lone pair and σ-bond

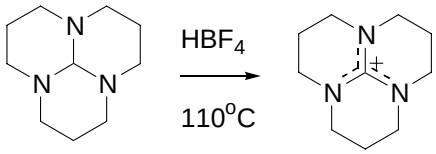


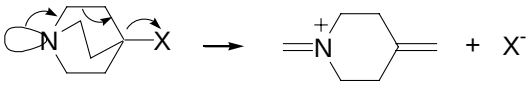
Bond lengths (Å) in cis-2,3-dichloro-1,4-dioxane



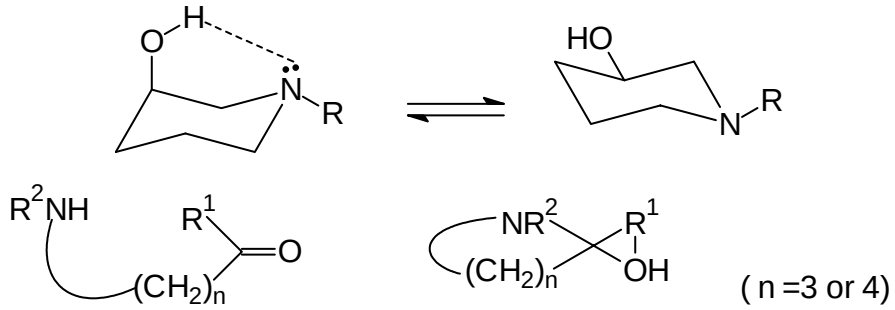
Antiperiplanar interactions of lone pairs and C-O bonds. Conformers (a) and (b) are equivalent and have axial OR; conformer (c) has equatorial OR







3.4.2 Attractive through-space interactions



Open-chain and cyclic tautomers of amino ketones