

Structure and Bonding

- Valence Bond Theory—bonds form w/ overlap of valence orbitals
- Hybridization—blend of atomic orbitals into new hybrid orbitals (on same local atom) to make a bond
- MO Theory—blend atomic orbitals into mole orbital (over whole mole)

Hybridization

- 1) H (S) and Halogens (P) do not hybridize
- 2) CH₃⁺ — 6e- SP²
- 3) must include resonance

Chem Rxns

- 1) Chem Thermodynamics—> extent of rxn or % formation of product, Enthalpy: exo—> towards prod, endo towards reactants
Thermodynamic Control— best product (most stable), most exo
- 2) Chemical Kinetics—> Governs rate of rxn—ROC in []—> activation E, RDS
Kinetic Control—> easiest prod. lowest E_a

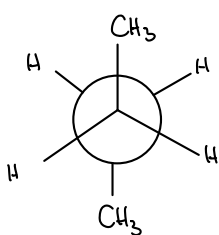
Acids and Bases

- 1) Arrhenius
acids—donate H⁺ in H₂O: HCl, HBr, HF, HCN, H₂SO₄, HNO₃, H₂S, R-COOH
bases—donate OH⁻ in H₂O: NaOH, KOH, Ca(OH)₂, Na₂O *Not CH₃OH (actually acidic; nonmetal covalent bonds)
 - 2) Bronsted-Lowry
acids—donate H⁺: almost everything with H—except SP³CH and 6e- species: BH₃, CH₃⁺
bases—accept H⁺: has lone pair
 - 3) Lewis Acids and Bases
acids—accept e- into empty orbital—6e- species (BH₃, CH₃⁺, AlCl₃, BF₃), metal ions, H⁺
bases—donate e- into empty orbital
 - 4) Nucleophiles and Electrophiles
E⁺—> acid like, accept e- into empty orbital or partial positive: H⁺, BH₃, CH₃⁺, CH₃Cl, C=O
Nu⁻—> base like, have e- and want to give them away— have lone pair or partial negative: OH⁻, Cl⁻, NH₃, C=O *CH₃Cl- has lone pairs but not Nu- cuz + unstable
- All Lewis Bases = BL Bases = Nucleophiles
All LA are E⁺ not all E⁺ are Lewis acids

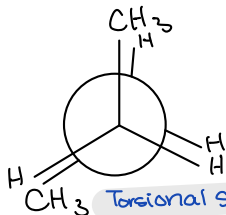
What makes a good acid

- 1) Size of Atom
- 2) En of atom
- 3) resonance
- 4) Hybridization—> more S orbital in hybrid—> more e- @ nucleus —> better acid
- 5) Induction: a) EN closer to acidic H, b) if EN atom more EN, c) larger # of EN atoms

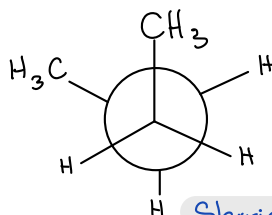
Rotamers/Conformers



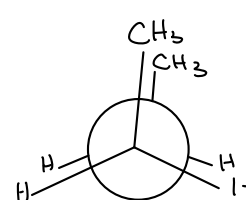
Staggered Anti



Eclipsed



Staggered gauche

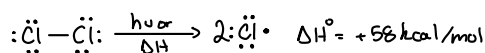


Sterric Hindrance
Torsional Strain

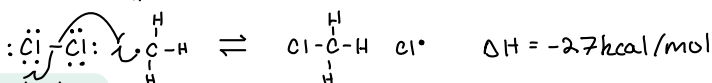
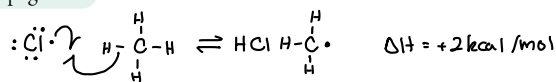
- All staggered lower in E than eclipsed
- gauche = higher E rotamers
- H < X < OH < NH₂ < CH₃ < CH₂R < CHR₂ < CR₃

Radical Chain Mechanisms

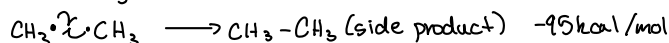
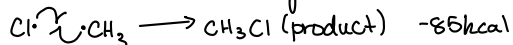
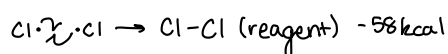
1) Initiation



2) Propagation



3) Termination



Hyperconjugation—> increasing # of alkyl groups increases the stability of radicals as SP³ hybrid orbitals line up and share e- into the radical, makes radicals less high in E and makes it easier for radicals to hang around

	1°	2°	3°
F	1	1.2	1.4
Cl	1	4	5
Br	1	80	1700

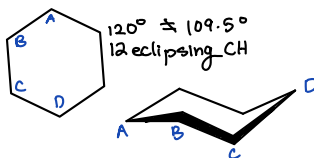
F: TS looks like starting material—> very exo, low E_a, early transition state, not selective

Cl: equilibrium selectivity, not very extreme, no major act E, not very Exo

I: TS: looks like product—> very endo, high E_a late transition state, very selective

Rings — Unsaturated C_nH_{2n}, cannot fully rotate

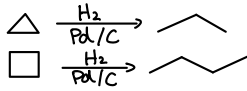
- Ring Strain = bond angle strain + torsional strain



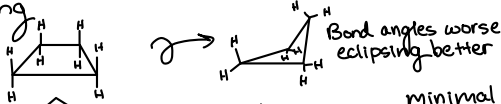
* wedge = up, * dash = down

- Flip ring
ax → eq
eq → ax

Hydrogenation



Puckering



Polarimetry — measures optical activities — observed angle of rotation not predictable by analysis of sharp of mole

- clockwise, + Dextrorotatory = D-isomer
- counterclockwise, - Levorotatory = L-isomer
- cannot tell from looking @ mole. if + or - not assoc with R or S
- racemic mix — optical activity of 0

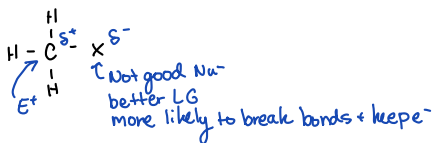
Chiral Resolution

- enantiomers - have same properties
 - add chiral surface, enzyme, chiral solvent, or chiral salt to get diastereomers of different properties
- purify and remove via chiral auxiliary
- racemic → add chiral, make diastereomer, separate diastereomer, remove diastereomer

Chirality in Reactions

- start w/ achiral molecule → get achiral product, if create stereocenter (racemic)
- start w/ chiral mole. → react @ chiral center from Sp²/achiral intermediate → prod racemic mix
- create new chiral center away from ori center → diastereomer + diastereoselectivity

Haloalkanes — ↑ halogen longer and weaker bonds = more polarizable orb, ↑ dispersion forces, ↑ BP, ↓ water solubility



R-X can react w/ Nu⁻

What affects reaction rate?

1) Better LG better SN₂: I > Br > Cl > F >>> OH >>> H >>> CH₃⁻; other good LG: MSO⁻, TFO⁻, TsO⁻
Good LG = Good Acid

2) Good Nucleophile — have extra e⁻ that want to be given away

Good bases usually good Nu⁻ but rilly strong bases may prefer to steal H rather than wait on an E⁺

1) more (-) charge

2) Less EN atoms

3) Larger more polarizable orbitals

4) Solvation - loose solvation shell allows for gaps/ places for solvent to move

Protic: F < Cl < Br < I (best Nu⁻)

Aprotic: I < Br < Cl < F (best Nu⁻)

5) Steric Hindrance: less branches @ reacting center = faster SN₂, alpha C steric hind. affects SN₂

*basicity abt thermodynamics H final prod ratio
nucleophilicity abt kinetics, E_a, transition state

Polar aprotic solv: CH₃CN, DMF, DMSO, CH₃NO₂, HMPA, CHCl₃, acetone

- particularly good for SN₂ bc they do not form strong solvation shells. Nu⁻ can approach E⁺ regardless of solvation

	Poor Nu ⁻	Weakly Basic Nu ⁻	Strong Base Nu ⁻	
			Unhindered	Hindered
CH ₃ -X (methyl)	NR	SN ₂	SN ₂	SN ₂ Poor Nu ⁻ : H ₂ O, ROH, HF Weak Basic Nu ⁻ : variable structure, pK _a < 15 NH ₃ , CN ⁻ , N ₃ ⁻ , R-COO ⁻ , SH ⁻ , H ₂ S, NH ₂ R, RSH, X ⁻
R-CH ₂ CH ₂ -X unhindered 1°	NR	SN ₂	SN ₂	E ₂ Strongly Basic Nu ⁻ : pK _a ≥ 15 small non EN atoms HO ⁻ , RO ⁻ , NH ₂ ⁻ , H ⁻ , C≡C ⁻ , CH ₃ Li, RMgBr
R-C(CH ₂) ₂ -X hindered 1°	NR	SN ₂	E ₂ Saytzev Regio most sub. alkene	E ₂ Hofmann Regio least sub. alkene OH ⁻ , CH ₃ O ⁻ , , NH ₃ , H ⁻ , C≡C ⁻
R-C(CH ₃) ₂ -X 2°	SN ₁ /E ₁	SN ₂	E ₂ Saytzev Regio most sub. alkene	E ₂ Hofmann Regio least sub. alkene Hindered 3° or LDA =
R-C(CH ₃) ₃ -X 3°	SN ₁ /E ₁	SN ₁ /E ₁	E ₂	E ₂

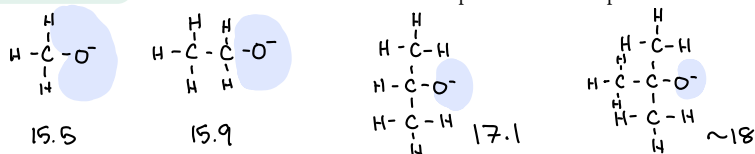
SN₂/E₂: R = K[R-X][Nu⁻]

SN₁/E₁: R = K[R-X]

Alcohols

- nomenclature—alcohols have priority
- alcohols are amphoteric, act as acids and bases

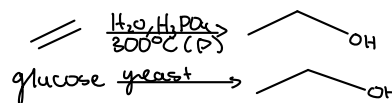
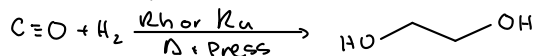
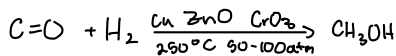
↑ Steric Bulk—> more extreme pKa * 3ROH hardest to protonate and deprotonate as minimal solvation leads to less help from surrounding charges to make an ion



- furthest pKa from 7, hardest to form
- hardest to form ion w/ minimal solvation
↳ weaker acid/base

Industrial Reactions

- 1000kg scale, lots of heat and pressure
- very simple molecules
- often start with gas and metal catalyst
- specific but not particularly stereoselective



Laboratory Reactions

- convert 1 fxn group to another, stereospecific+ regioselective
- work @any alcohol
- flexible w/ alkyl group
- fairly repeatable w/ variety of same fxn group

Redox

- reduction—gain of bonds to H, loss of bonds to EN
- oxidation—loss of bonds to H, gain of bonds to EN
- Polar Rxn—H+/H- works best with polar ketone
- Non polar Rxn—H2—works best w/ non polar

Reducing Agents: LiAlH_4 , NaBH_4

Oxidizing Agents: O_2 , O_3 , X_2 , MnO_4 , HNO_3 , Jones Reagent, PCC

- H- is a strong reducing agent, lots of oxidizing agents in the air

Organometallics

- not full ionic bond—very polar covalent w/ C partial(-), not full(-) helps stabilize molecule
- very reactive, not full ions~ CB w/ pKa ~50

Synthetic Strategy

- 1) Fewer rxns work better
- 2) convergent better than linear
- 3) watch out for incompatible rxns or side rxns

Ethers

- aprotic, no H-bonds, no acidic H, slightly polar, common solvent, volatile/flamable
- do not react w/ much NR to: base, ox, red, Nu-, WA
 - only react w/ O_2 (peroxide), and SA(HCl , HBr , HI , H_2SO_4)

Epoxides

- react w/ SA and act like good LG w/ Nu-(ring strain encourages opening)
- Basic conditions—> anions, Nu-, basic PKA>7, SN_2 , attack least substituted C(less steric hindrance)
 - OH^- , RO^- , SH^- , CN^- , LiAlH_4 , RLi or RMgBr , NH_2^- , NH_3
- Acidic Conditions—>Nu-H, more likely to see C^+ , SN_2 attack most substituted C(larger partial positive in transition state)
 - H_2O w/ H_2SO_4 , HOR w/ H_2SO_4