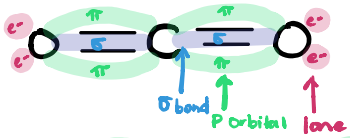
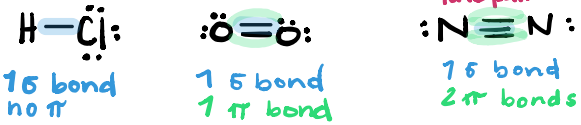
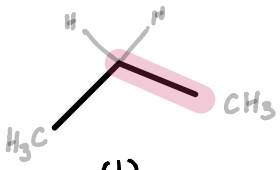
BONDING

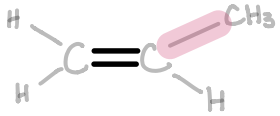




Q: Which of the following bonds are strongest?



(1)



(2)

(3)

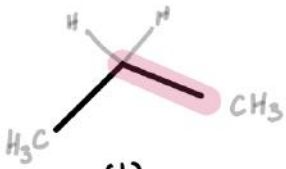
A: Propyne (3) is shorter and stronger than the others.

This is because its orbitals sp and sp^3 have the most overlap. Propene (2) is the next strongest followed by propane (1).

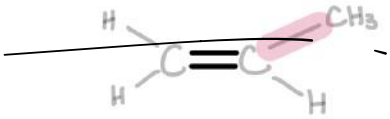
Q: Are "pi" bonds or "sigma" bonds stronger?

A: $\pi < \sigma$ HOWEVER $1\sigma + 1\pi$ is stronger than a single σ bond.

Q: Which bond is the most reactive?



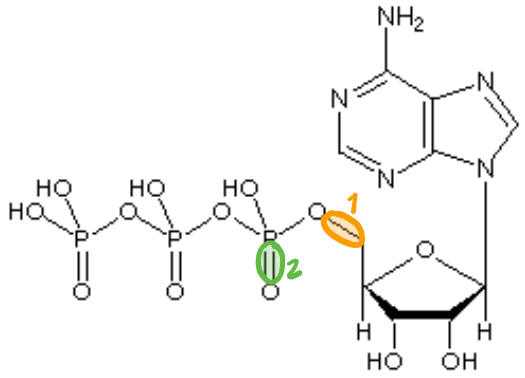
(1)



(2)

(3)

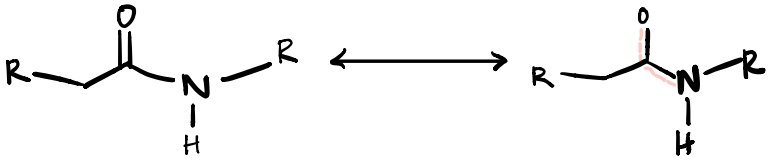
A: 3! triple bonds have an extra π bond which tends to react.



Q: Why in this ATP molecule is bond 1 more likely to dissociate than bond 2?

A: There are several reasons but the bond enery of bond 2 is much higher making it harder to break than bond 1.

Q: Do peptide bonds rotate?



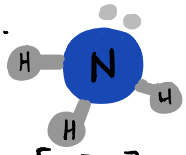
A: NO! Resonance gives double bond character to both the C-O and C-N bonds.

HYBRIDIZATION

a.

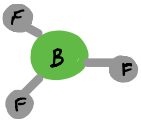
[?]

b.



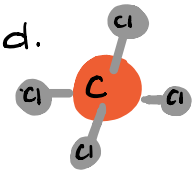
[?]

c.



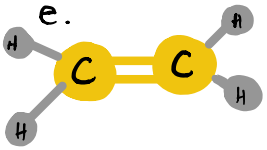
[?]

d.



[?]

e.



[?]

a. [sp]

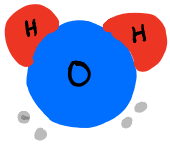
b. [sp^3]

c. [sp^2]

d. [sp^3]

e. [sp^2]

*This phenomenon occurs due to high and low energy orbitals mixing.



Sp^3 hybridized

Q: What is the "S" character?

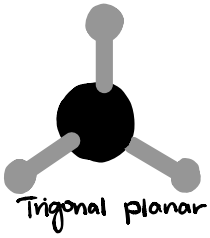
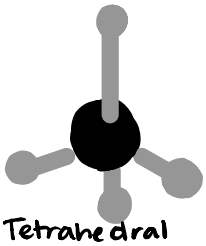
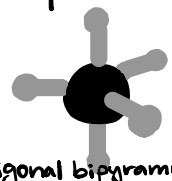
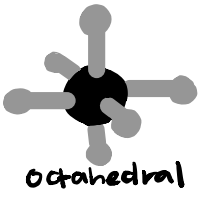
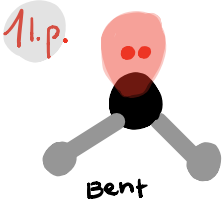
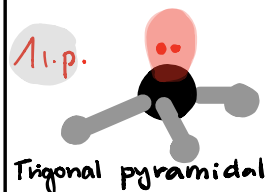
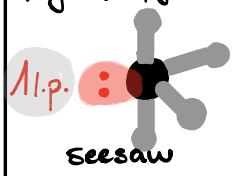
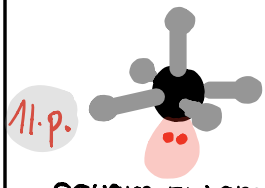
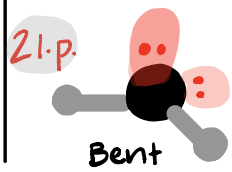
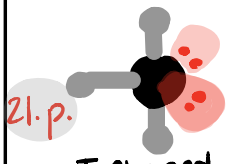
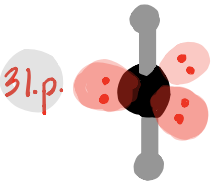
A: 25% "S" character
+
75% "P" character

$[S + p + p + p = sp^3]$

↑ ↑ ↑ ↑ = 1/4 = 25% s

1 1 2 3

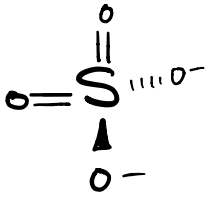
Shapes

sp^2	sp^3	sp^3d	sp^3d^2
TRIGONAL PLANAR	TETRAHEDRAL		OCTAHEDRAL
 Trigonal planar	 Tetrahedral	 Trigonal bipyramidal	 Octahedral
 1 l.p. Bent	 1 l.p. Trigonal pyramidal	 1 l.p. Seesaw	 1 l.p. Square pyramidal
	 2 l.p. Bent	 2 l.p. T-shaped	 2 l.p. Square planar
		 3 l.p. Linear	

Q: What shape do the following molecules take:

a. SO_4^{2-}
b. BrF_5
c. IF_2^-
d. O_3
e. SF_4
f. SOF_4
g. NO_3^-
h. H_3O^+
i. ClF_3
j. CH_4
k. $SnBr_2$

Answers

a.  Tetrahedral

b. BF_5 sp^3d^2 — Square pyramidal

Br = 7 VE

F = 7 VE

7(1) + 7(5) =

lone pairs = l.p.

35 + 7 = 42 − 40 = 2 e⁻ = 1 l.p.

(multiple of 8 — Octet)

c. IF_2^-

I: 7 — F: 7×2 — −: 1

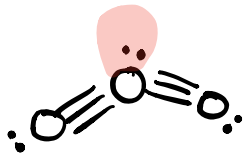
14 + 1 + 7 = 22 − 16 = 6 e⁻ = 3 l.p. !

sp^3d

linear

d. O_3

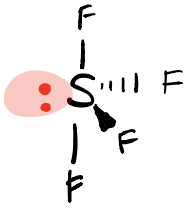
6×3 = 18 − 16 = 2 e⁻ = 1 l.p.



sp^2 — Bent

e. SF_4

$6 + 4(7) = 28 + 6 = 34 - 32 = 2e^- = 1$ l.p.

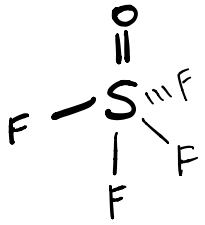


sp^3d — seesaw

f. SOF_4

$6 + 6 + 7*4$

$12 + 28 = 40 - 40 = 0e^- = 0$ l.p



sp^3d — trigonal bipyramidal

g. NO_3^-

$5 + (6*3) + 1$

$5 + 18 + 1 = 24 - 24 = 0e^- = 0$ l.p.

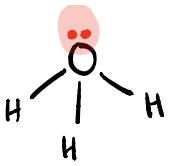
$(8*3)$

sp^2 — trigonal planar

h. H_3O^+

$(1*3) + 6 + 1$

$1 + 3 + 6 = 10 - 8 = 2e^- = 1$ l.p.

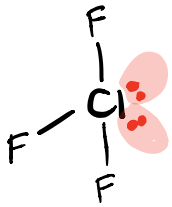


sp^3 — trigonal pyramidal

i. ClF_3

7 + (7 × 3)

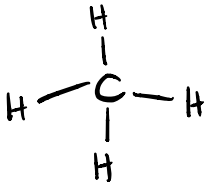
7 + 21 = 28 − 24 = 4 e^- = 2 l.p.



sp^3d — T-shaped

j. CH_4

4 + 4 = 8 − 8 = 0 e^- = 0 l.p.

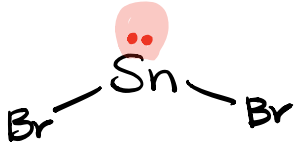


sp^3 — tetrahedral

K. $SnBr_2$

4 + 14 = 18 − 16 = 2 e^- = 1 l.p.

Sp^2 — Bent



Single bonds | Double bonds | Triple bonds

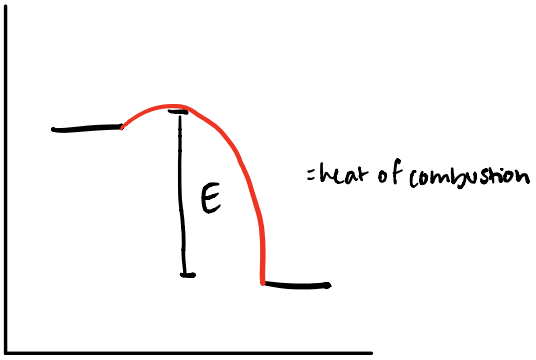
BOND LENGTH

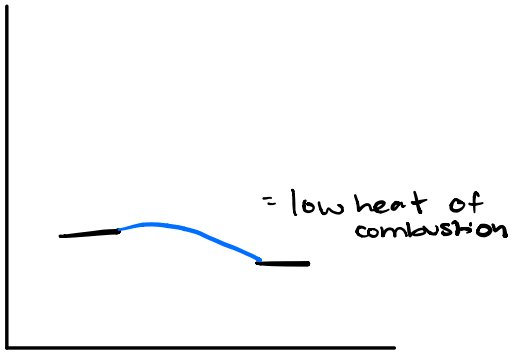
STABILITY

REACTIVITY

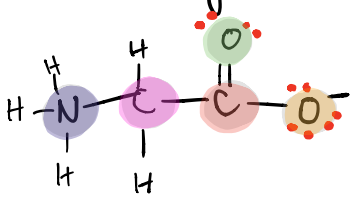
STRENGTH

Bond strength = harder to break (shorter)





Formal Charge of glycine



N = 5 − 4 = FC of 1+

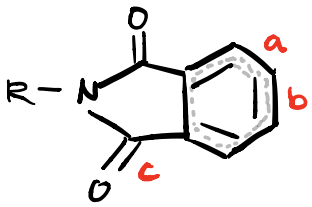
C = 4 − 4 = FC of 0

C = 4 − 4 = FC of 0

O = 6 − 6 = FC of 0

O = 6 − 7 = FC of −1

Q: Order the bonds from longest to shortest:



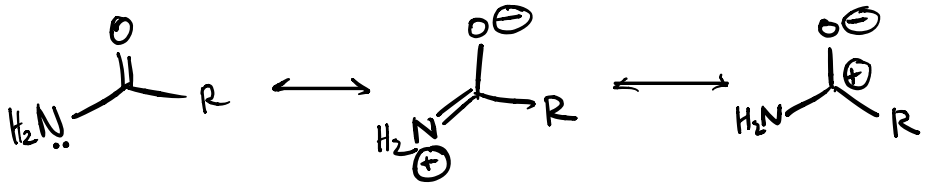
Longest ⟶ shortest

A: $a = b > c$

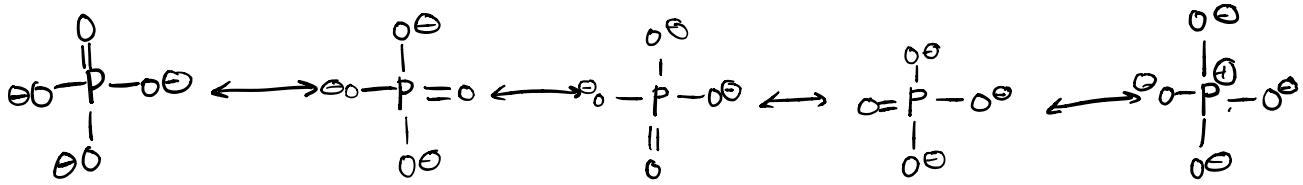
↑ due to resonance

Q: Draw all resonance forms for:

a. $R-CONH_2$ [AMide]



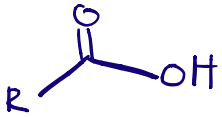
b. PO_4^{3-} [Phosphate]



NOMENCLATURE

priority (IUPAC)

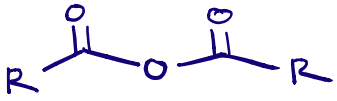
(1) Carboxylic acid



Prefix: Carboxy

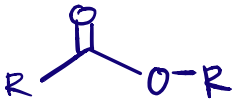
Suffix: oic acid

(2) acid anhydride



Suffix: oic anhydride

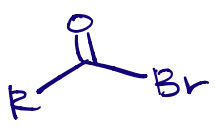
(3) Esters



Prefix: alkoxy carbonyl

Suffix: oate

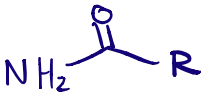
(4) Acyl Halides

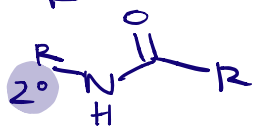


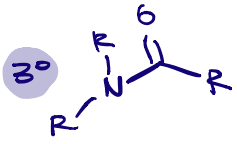
Suffix: oyl Chloride

(5) Amides

Prefix: Carbamoyl
Suffix: amide

1° 

2° 

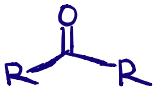
3° 

(6) Nitriles $R-C\equiv N$

Prefix: Cyano
Suffix: Nitrile

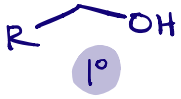
(7) Aldehydes 

Prefix: oxo
Suffix: al

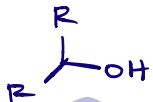
(8) Ketones 

Prefix: oxo
Suffix: al

(9) Alcohols



1°



2°

3°

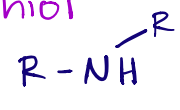
Prefix: hydroxy
Suffix: ol

(10) Thiol R-SH

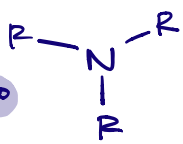
Prefix: mercapto
Suffix: Thiol

(11) Amines

1° $R-NH_2$



2°

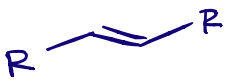


3°

Prefix: amino
Suffix: amine

(12) Sulfides

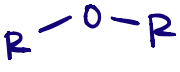
(13) Alkenes



Prefix: enyl
Suffix: ene

(14) Alkynes

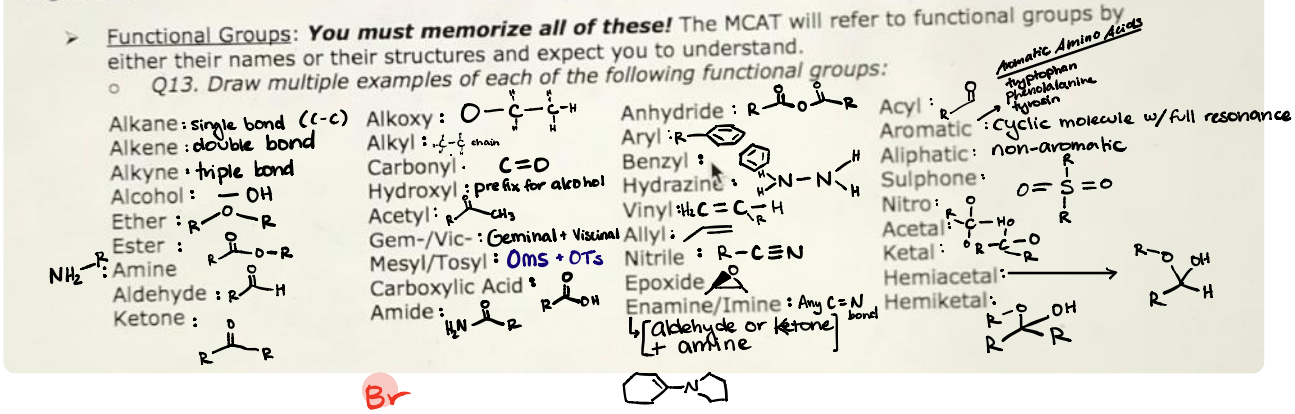
Prefix: ynyl
Suffix: yne

(15) Alkanes 

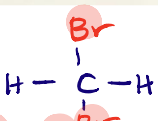
Prefix: yl
Suffix: ane

Organic Nomenclature

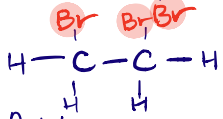
- Functional Groups: ***You must memorize all of these!*** The MCAT will refer to functional groups by either their names or their structures and expect you to understand.
  - *Q13. Draw multiple examples of each of the following functional groups:*



Geminal:



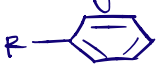
Vicinal



Mesylate: Add a methyl group ($-OSO_2CH_3$) also known as Oms
↳ excellent leaving group. (+ no acidic proton)

Tosylate: OTs (similar to Oms)

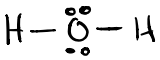
Aryl: Any functional group derived from an aromatic ring



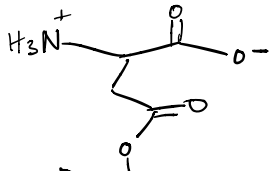
Vinyl: = group

Allyl: /= group

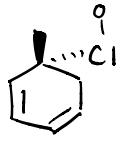
Q: Lewis Dot Structure ⟶



Line-Bond Order ⟶

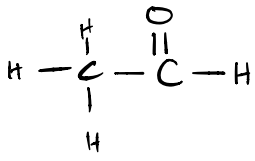


Wedge-Dash Formula ⟶

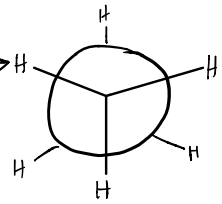


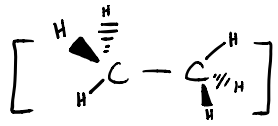
Condensed Formula ⟶ CH_3COO^-

Fischer Projection ⟶

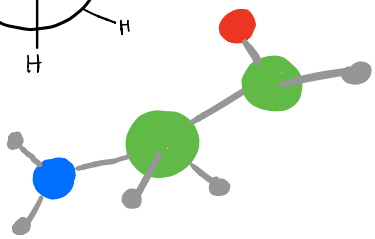


Newman Projection →





Ball and Stick Model →



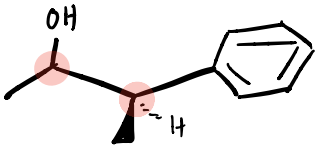
Space filling Model →

Isomers:

* Same molecular formula, different compounds

Q: How do we determine how many isomers something has?

A: 2^n (where n = # chiral centers)



How many stereoisomers?

$2^n = 2^2 = \boxed{4}$

#1 Conformational isomers
(NOT true isomers)
Conformational isomers are the exact same molecule.

Butane

#2 Structural Isomers
Same formula but different connectivity

C_6H_{14}

2-methylpentane

3-methyl pentane

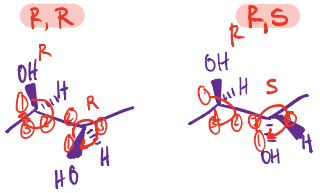
#3 Stereoisomers

Same formula, same connectivity, different 3D arrangements

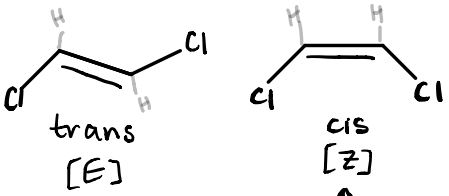
→ Enantiomers: same molecular formula + same connectivity but are non-identical. Non-super imposable mirror images

(R+S)

→ Diastereomers



Geometric Isomers: (cis/trans)



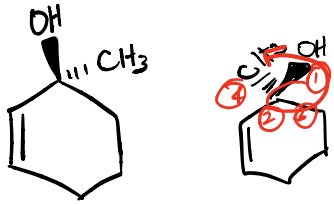
↑ no dipole moment (SI)

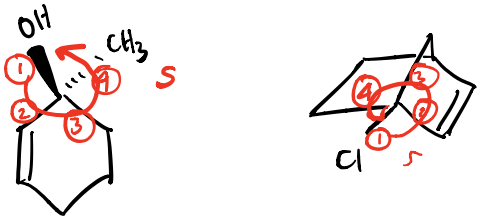
↑ no steric hindrance

↑ often have a dipole movement

↑ often experience "steric hinderance" (↑ energy)

practice assigning





Reaction Types

E1: Elimination Rxn ~ Unimolecular
1st order (one species is concentrated)
2 steps
① Dissociation of leaving group, form carbocation (slow)
② Abstract a proton + form double bond (fast)

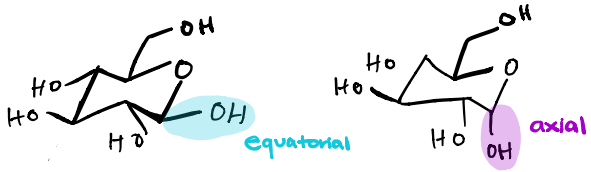
E2: Elimination Rxn ~ Bimolecular
2nd order (two species are concentrated)
1 step
① Abstraction of a proton + electron collapse to form a double bond and ejection of the leaving group.

SN1: Substitution Rxn ~ Unimolecular
1st order
2 steps
① Dissociation of leaving group and formation of carbocation
② Nucleophilic attack of the carbocation

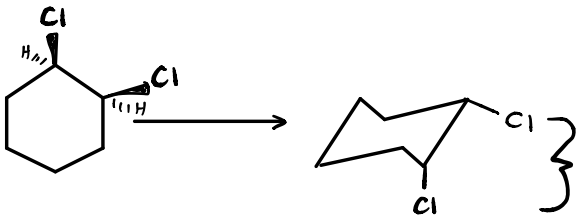
SN2: Substitution Rxn ~ Bimolecular
2nd order (two involved concentrated species)
1 step
① Single step back side attack of electrophile + ejection of leaving group.

	#steps	Rxn order	carbocation?	methyl or hydride shifts?	product stereochemistry	Favored by:
E1	2	1st	yes	yes	planar	weak bases 3° carbons polar protic
SN1	2	1st	yes	yes	racemic mix	poor nucleophiles 3° carbons polar protic solvents
E2	1	2nd	no	no	planar	strong and/or bulky bases
SN2	1	2nd	no	no	inversion of configuration	good nucleophiles methyl 1° or 2° carbons

Cyclic Compounds:



a large substitute would be most comfortable in the axial position as it eliminates repulsion.



need to be equatorial to one another.

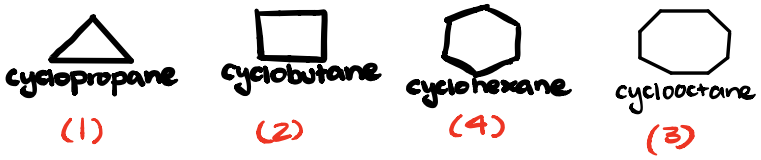
COMBUSTION OF ALKANES

$CH_4 + 2O_2 \longrightarrow CO_2 + 2H_2O$ + Heat

- ↑ energy of activation
- exothermic

Q: Will N_2 have a high heat of combustion?

- Stable molecule = low heat of combustion
- N_2 = stable
- N_2 = low heat of combustion



Highest heat of combustion = 1
Lowest = 4

Radicals = single unpaired electron (NOT ON MCAT)
→ Free radicals may be a consequence of cell damage

Donating groups donate their electron density into a conjugated π system

C_6H_5 =  Unsaturated

BP ↑ with ↑ MW
BP ↓ with ↑ branches

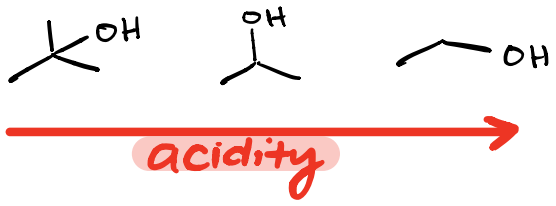
Q: Why is alcohol highly soluble in water?

A: Polarity, hydrogen bonding

Acidity

$OH < H_2O$

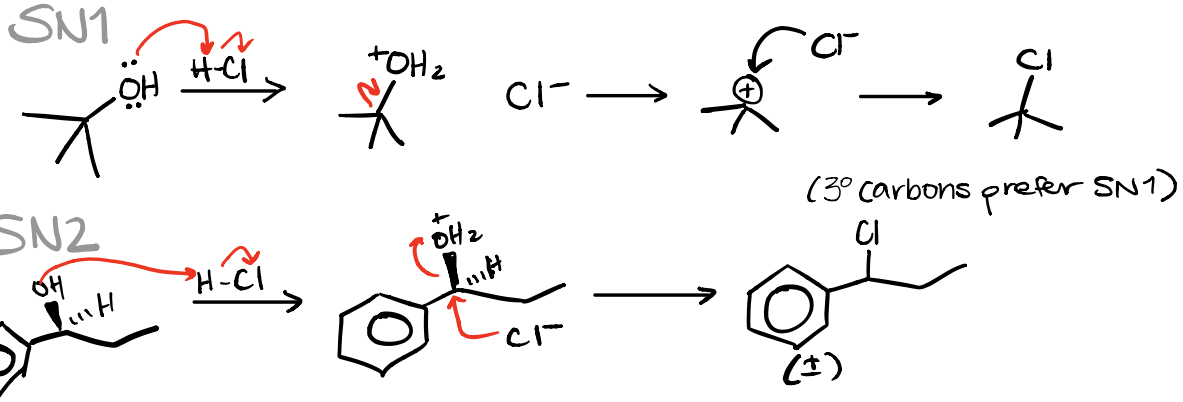
H^+ = acidic so H_2O has more proton than OH and OH^- causes an increase in pH.



This is because at less substituted areas the proton can be more easily donated (leaving $\sim O^-$) whereas the (-) charge on a tertiary molecule would be crowded and repulsive and less stable. This is due to the alkyl groups being weak electron donating group

REACTIONS [Galore]

Formation of an alkyl Halide from an alcohol



Oxidation of alcohols

1° alcohols → aldehydes → carboxylic acids

2° alcohols → ketones

3° alcohols → cannot be further oxidized

Common Oxidizing Agents:
- O_3
- Cr_2O_7
- CrO_4
- $KMnO_4$
- Jones
- Collins
- PCC
- PDC

Q: *Q28. Potassium dichromate is often used as an oxidizing agent. A solution of dichromate ions ($Cr_2O_7^{2-}$) is orange, but a solution of chromium ions (Cr^{3+}) is green. If alcohol A is reacted with potassium dichromate and produces a green solution, and alcohol B is reacted with the same reagent and produces an orange solution, what can be inferred about the two alcohols, A and B?*

A:

$A-OH + K_2Cr_2O_7 = \text{green}$

$B-OH + K_2Cr_2O_7 = \text{orange}$

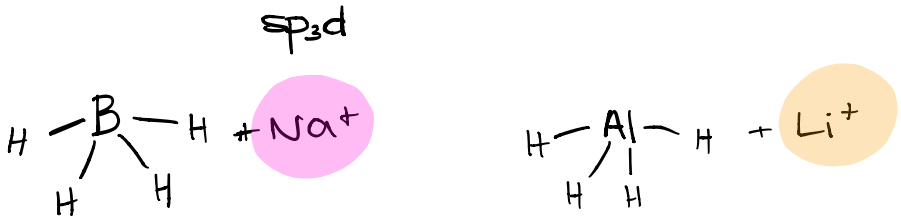
dichromate ions are becoming chromium ions by oxidation. so unreacted dichromate is orange alcohol B is likely tertiary as it did not oxidize (react). Alcohol A is likely 1° or 2°.

Reduction synthesis of an alcohol

*Reducing agents do the opposite of oxidizing agents

Reducing agents:
- $NaBH_4$ (only can reduce aldehydes + ketones)
- $LiAlH_4$
- H_2 + pressure

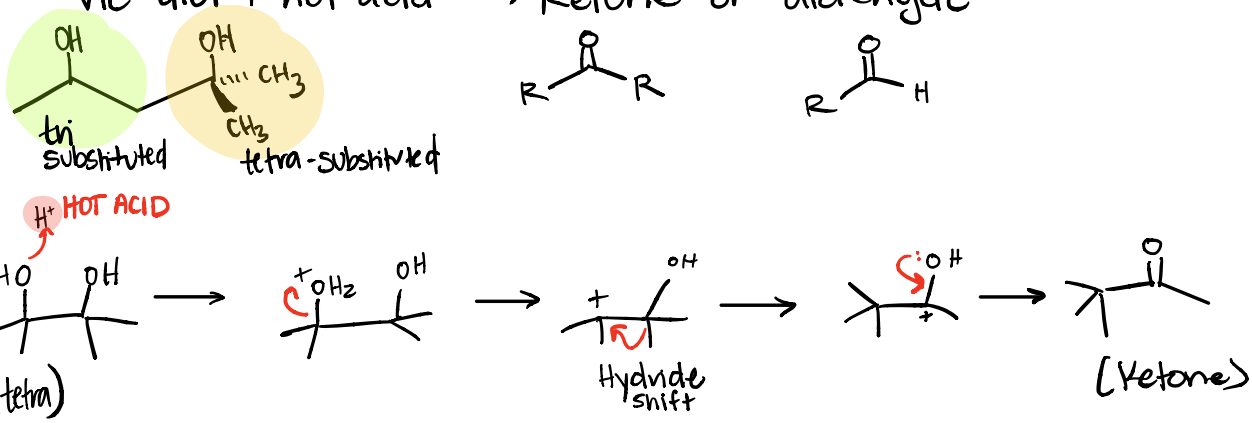
} can reduce aldehydes, ketones, carboxylic acids and esters.



Boron is more electronegative, keeping the electron density inwards making the hydrides less nucleophilic. $LiAlH_4$ is a stronger reducing agent therefore as its hydrides can reduce "2x".

Pinacol Rearrangement

vic-diol + hot acid ⟶ Ketone or aldehyde



Alcohol Protection

* used to protect alcohols from oxidation or reaction but allowing other groups on the molecule to react.

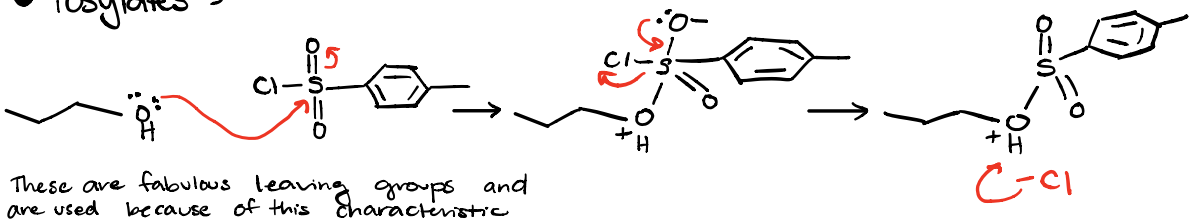
(#1) TMS

(#2) MOM

& acidification removes protecting group and restores alcohol.

- Mesylates
- Tosylates

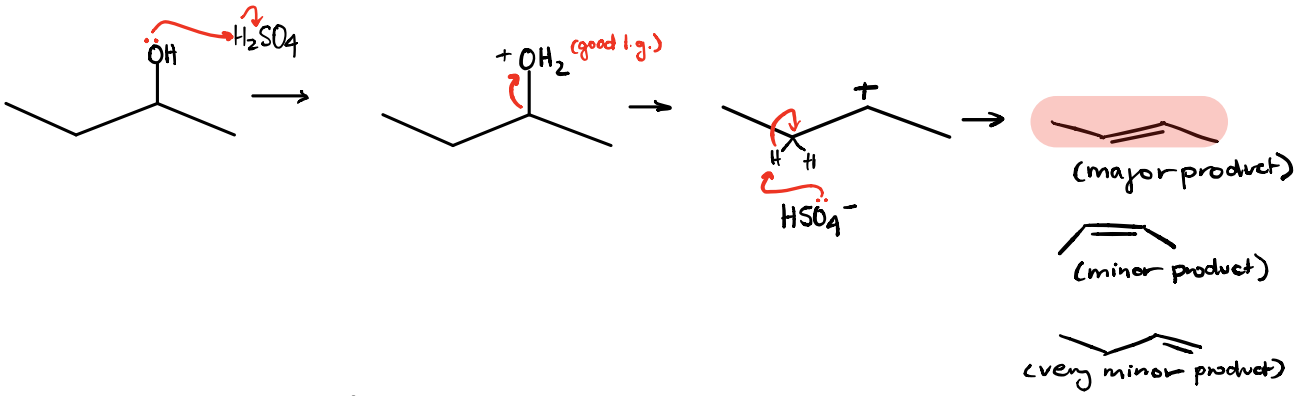
} SN2



These are fabulous leaving groups and are used because of this characteristic

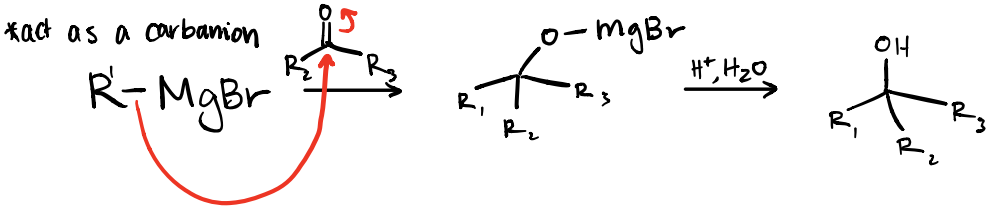
Dehydration Rxn

* Equilibrium reaction!!
  alcohol favored by cold dilute acid
  alkene favored by hot concentrated acid
* Major product = most stable alkene

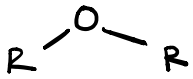


Gringnard Synthesis

* increases # of carbons
* produces an alcohol



Ethers



- non reactive
- weakly polar
- low boiling point

Organic solvents

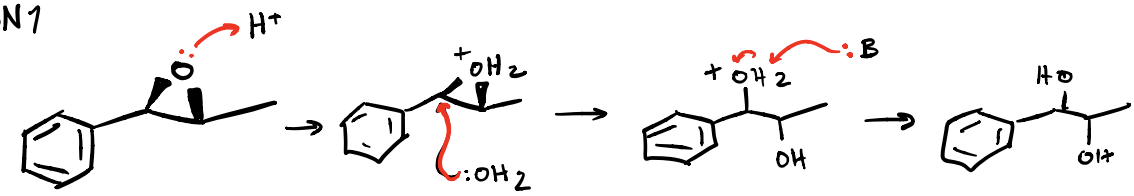
pI = isoelectric point

* like dissolves like
* unreactive

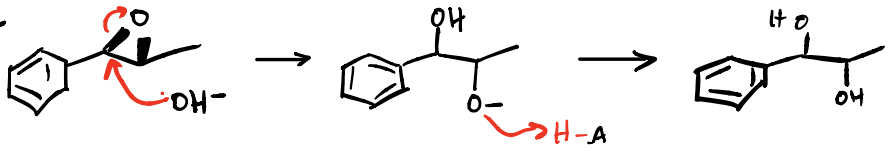
Epoxides

- very reactive
- O gets protonated + becomes a better leaving group.

SN1



SN2



Which is more reactive?

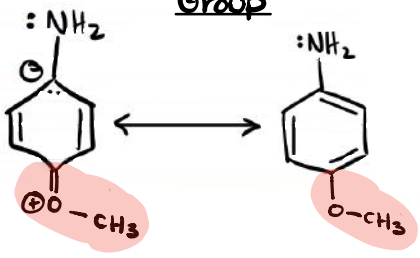
① $\delta^+C{=}O\delta^-$

② C=N

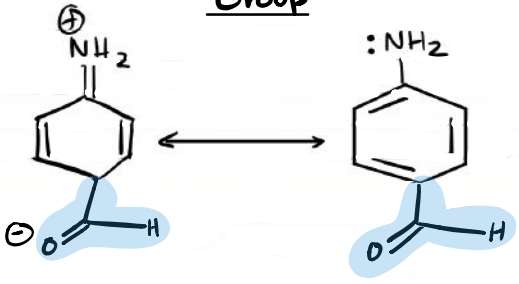
Electrophiles:
δ^+ or +

Nucleophiles:
δ^- or −

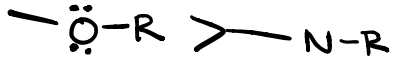
Electron Donating Group



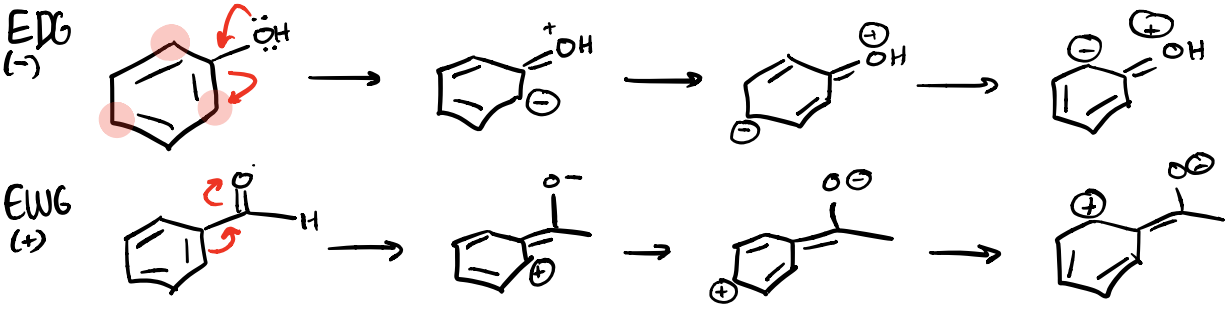
Electron Withdrawing Group



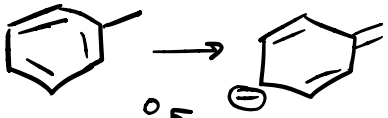
*lone pair



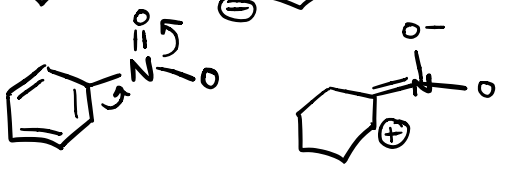
Nitrogen is less electronegative making it more available to donate its electrons



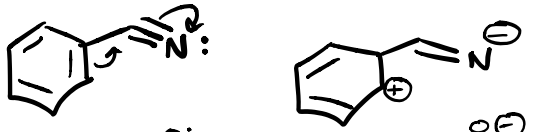
EWG or EDG??



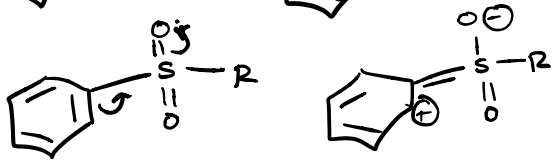
EDG (alkyls)



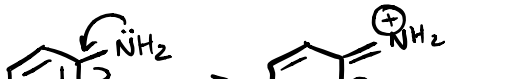
EWG (Nitro) (strong)



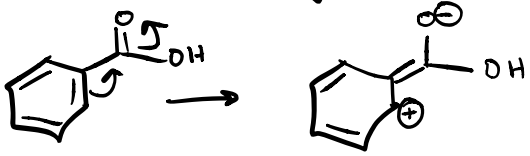
EWG (cyano)



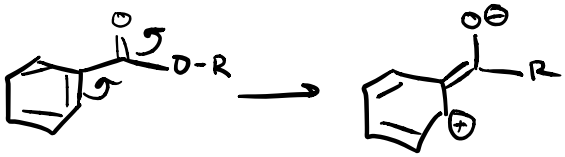
EWG (sulphones)



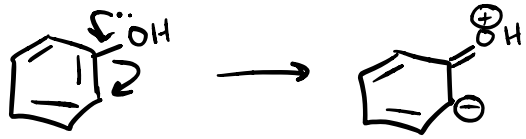
EDG (amines)



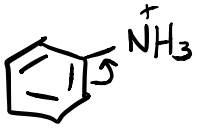
EWG (carboxylic acids)



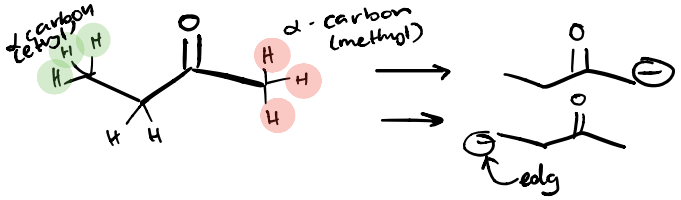
EWG (esters)



EDG (alcohols)



EWG (quaternary amines)

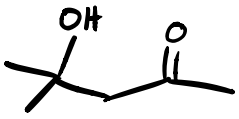


H-A → B⁻

3° carbon must react via SN1 or E1

Less stable cb = less acidic

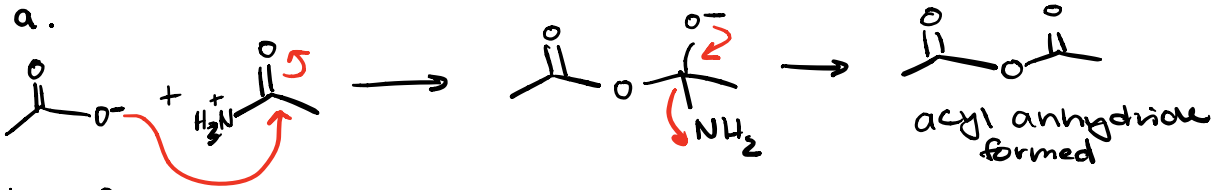
↑ cb stability = ↑ acidity



Resonance stabilizes ♡

Q: which is more likely to occur?

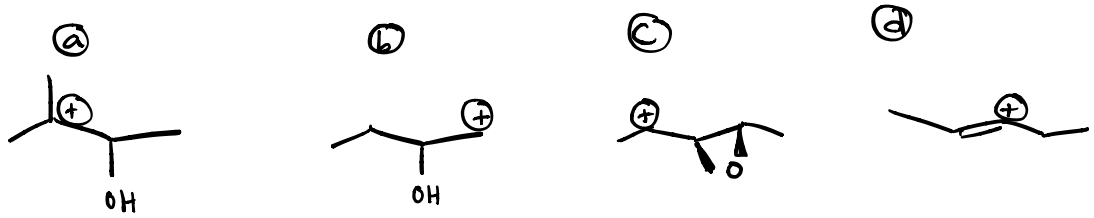
a.



b.

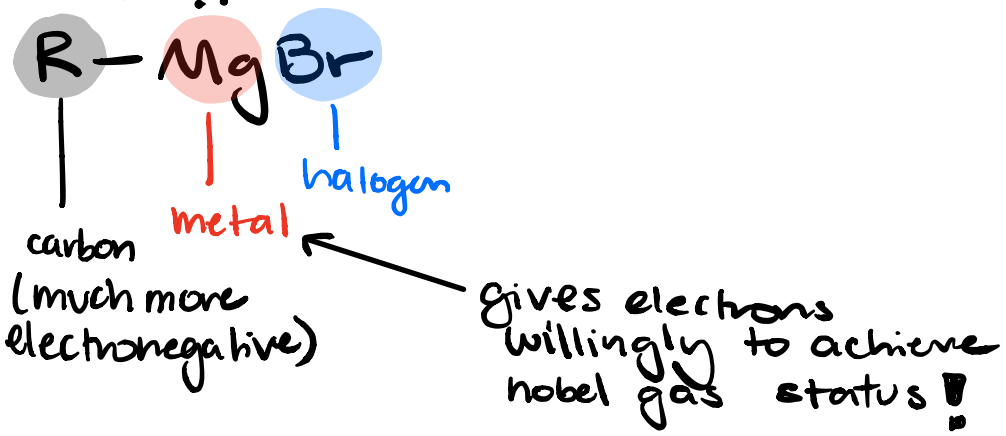
A: B! First and foremost a base!

Q: Which carbocation is most stable?



A: A!
tertiary substituted!

Gringard synthesis



IR Spectroscopy

infrared

a bond must have a dipole to be detected by I.R.

Spectra To Know

- carbonyl : 1700cm^{-1} (C=O)
  *sharp + deep
- alcohol : 3300cm^{-1} (O-H)
  broad, separate from C-H
- Saturated alkane: 2800cm^{-1} (C-H)
  sharp + deep
- carboxylic acid : 3000 cm^{-1} (O-H)
  broad, overlaps CH
- amine : 3300 cm^{-1} (N-H)
  broad + shallow
- amide : 3300cm^{-1} (N-H)
  * broad + deep *
- nitriles : 2250 cm^{-1} (C≡N)
  sharp + deep

when . . .

IR radiation = frequency of vibration in a bond

the bond is in resonance so it will absorb some IR energy.

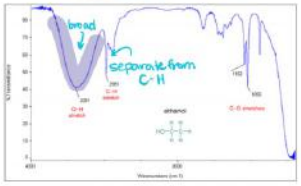
read by the detector

Bond frequency of vibration

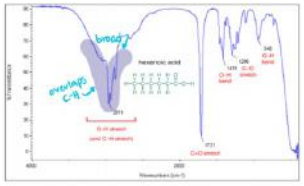
determined by...
1. bond strength
2. molecular weight of bonded atoms

↑ bond strength = ↑ freq

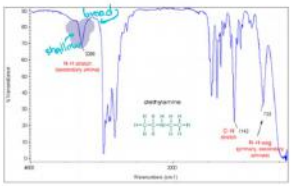
↑ mass = ↓ freq



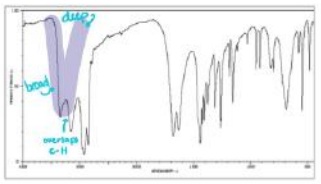
Alcohol



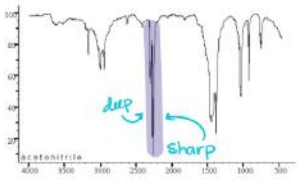
Carboxylic Acid (Note O-H and C=O)



Amine (notice how shallow it is)



Amide (slightly overlapping C-H stretch)

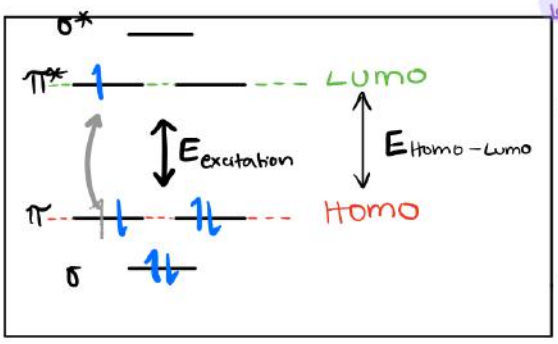


Nitrile

UV Spectroscopy

ultraviolet

UV radiation

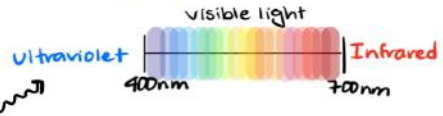


energy between molecular orbitals ≈ energy created by electromagnetic radiation in UV spectrum.

So...

when exposed to UV radiation electrons excite to next energy level. The absorbance is recorded.

Single bonded molecules have low or no UV absorbance
double bonds < triple bonds. Both show strong absorbance
conjugated systems absorb even more light than others
UV spectrum is a graph of absorbance vs wavelength

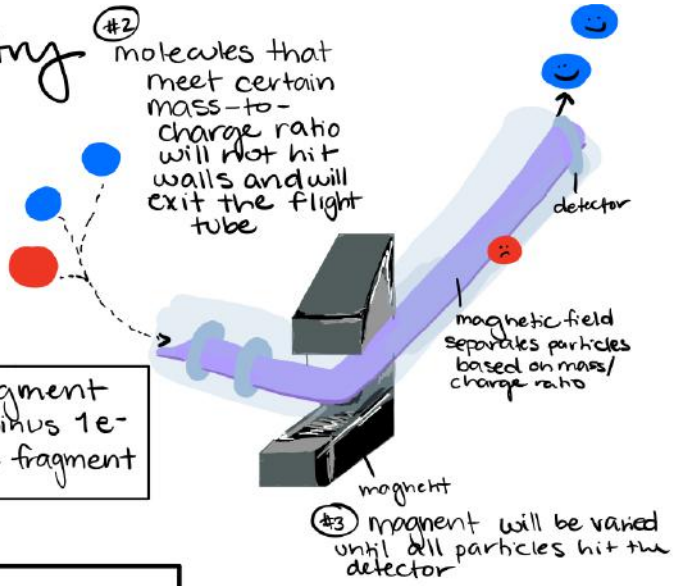


↑ conjugation of a system = ↑ wavelength

Mass Spectrometry

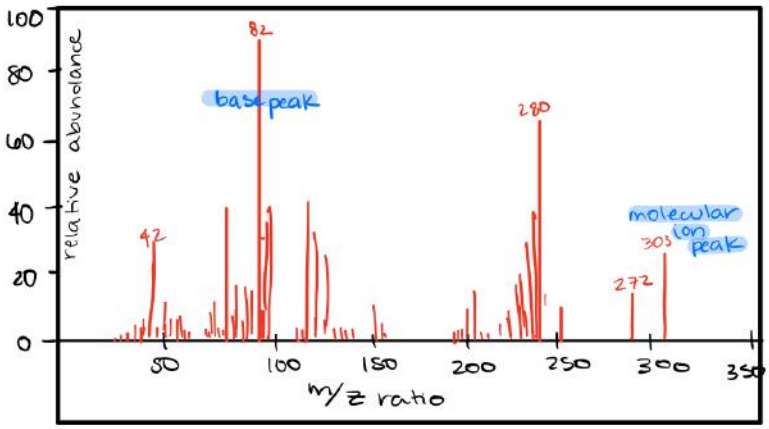
(#1) bombard molecule with electrons to break it and ionize pieces.

(#2) molecules that meet certain mass-to-charge ratio will not hit walls and will exit the flight tube



(#3) magnet will be varied until all particles hit the detector

- Height of peak = abundance of fragment
- Parent peak = original molecule minus 1e-
- Base peak = most common + stable fragment
  - → highest peak



NMR Spectroscopy

nuclear magnetic resonance

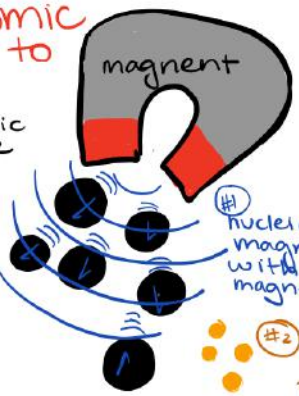
→ differentiate molecules based on chemical environment of their (H) or (C)

90% of NMR on MCAT

atoms must have an odd atomic number or odd mass number to register on NMR.

all nuclei with odd atomic mass or mass # have a nuclear spin.

↳ nuclear spin causes small changes in the electrical field which creates a magnetic field.



#1 nuclei align their magnetic fields with the external magnetic field.

#2 when nuclei are exposed to photons some can absorb the energy and flip their field against magnetic field which is detected by the NMR.

#3 difference in energy needed to flip nuclei is based on degree of shielding

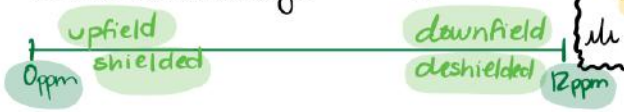
H-NMR

Peaks: all hydrogens in a molecule with a distinct chemical environment.

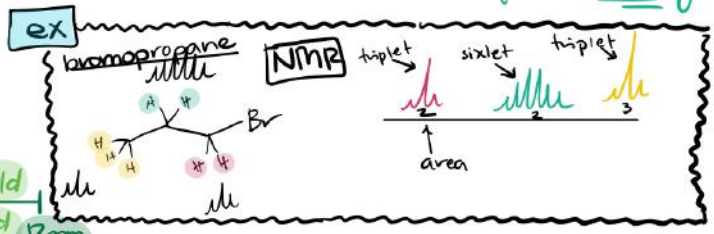
spin-spin splitting: # of neighboring hydrogens.

area under peak: # of hydrogens in that chemical environment. (relative to other peaks.)

absorbance range: 0-12 ppm



ex



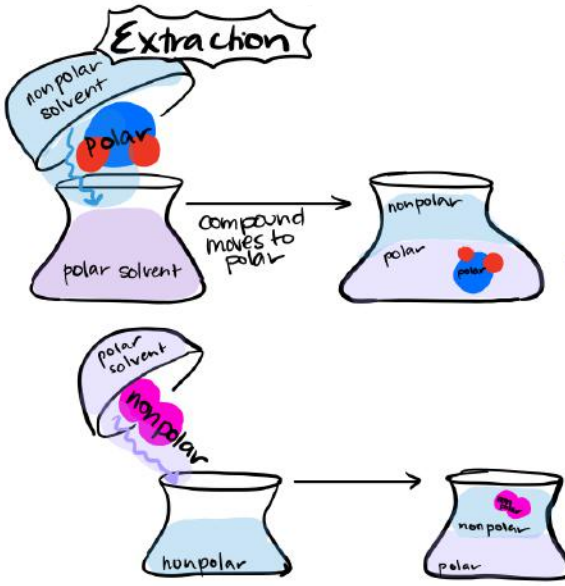
C^{13}-NMR

- no spin-spin splitting — singlet peaks
- no integration — area under curve not important

0-220 ppm

! absorbances to know ! (still rare... just know in case)

C-C ⟿ 0-50 ppm
C-O ⟿ 50-100 ppm
C=C ⟿ 100-150 ppm
C=O ⟿ 150-200 ppm



flow through containing product

polar layer drained
solvent layer evaporated to obtain product.

(experimental design)

How to improve Separation

#1 Repetition

#2 Fractional extraction (use a 5mL X10 over a 50mL)

#3 Add an acid to protenate the product

#4 add a base to deprotenate the product

*acids protenate bases to increase solubility in aqueous (polar) layer.

*bases deprotenate bases to increase solubility in polar layer

Chromatography

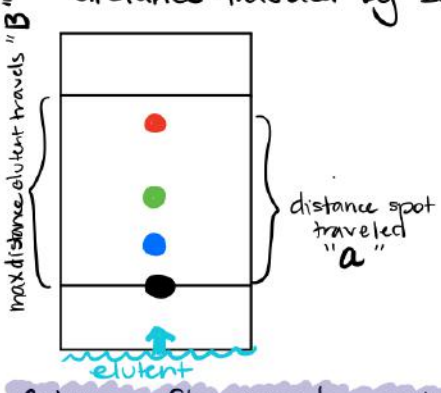
TLC

thin layer

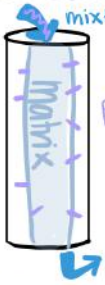
- paper = stationary phase

$R_f = \frac{\text{distance traveled by component}}{\text{distance traveled by solvent}}$ } closer to 1 means polarity of compound + solvent are similar

$\frac{a}{b}$ = $R_f = .9$ ⇝ non-polar compound

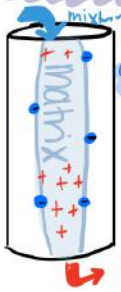


Column Chromatography



polar compound stuck on polar matrix but will follow

Ion-exchange Chromatography

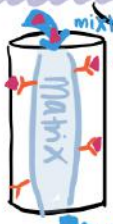


matrix = cation coated

anions in mixture stuck to matrix

Elute: wash with salt solution

affinity Chromatography

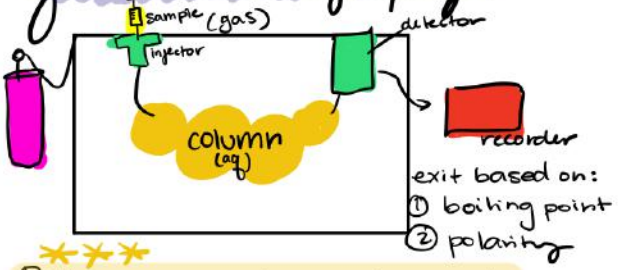


target molecule stuck on matrix

Elute: salt solution or reverse chemical reaction.

mixture w/o molecule being targeted

gas chromatography



exit based on:
① boiling point
② polarity

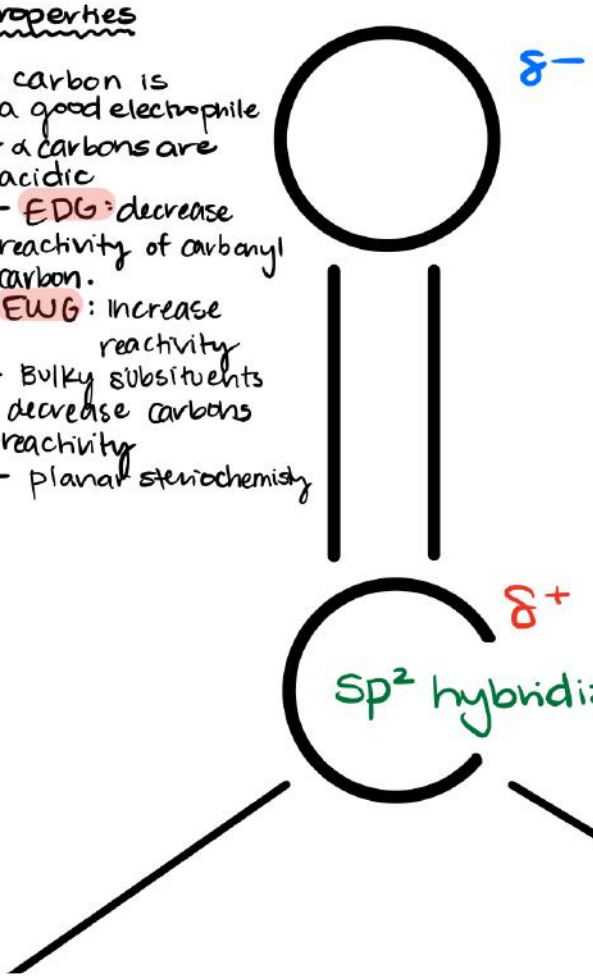
Peaks in gas chromatography are based on is equal to abundance of the compound

Lil Carbonyls

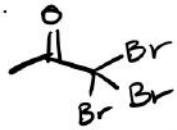
- Carbonyls > alkenes because oxygen is smaller and has better orbital overlap.

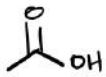
properties

1- carbon is a good electrophile
2- α carbons are acidic
3- EDG: decrease reactivity of carbonyl carbon.
EWG: increase reactivity
4- Bulky substituents decrease carbons reactivity
5- planar stereochemistry



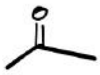
most acidic

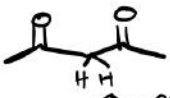
a. 

b. 

c. 

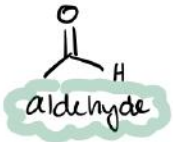
least acidic

d. 



↑ even more acidic

α-carbon!
acidic hydrogens



solubility trends

alkanes < aldehydes + ketones < alcohols
(no H-bond; H-bond acceptor; H-bond donor and acceptor)

increasing →

boiling point

alkanes < aldehydes + ketones < alcohols

increasing →

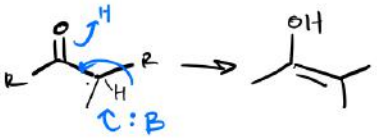
—al

- H-bond acceptors
  H_2O H-bond donor
- electrophiles
- function as Lewis acid

—one

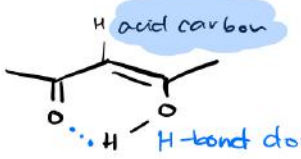
- H-bond acceptors
  H_2O H-bond donor
- electrophiles
- function as Lewis acid

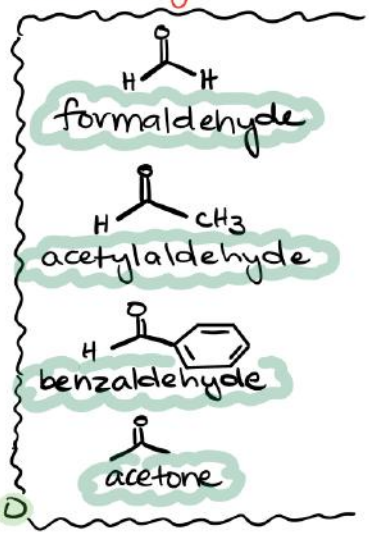
Keto-enol tautomerization

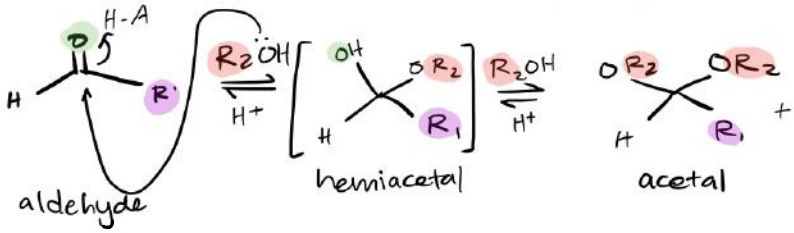


Keto
more stable

enol



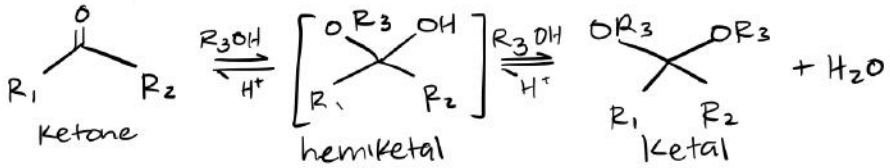




aldehyde

hemiacetal

acetal



ketone

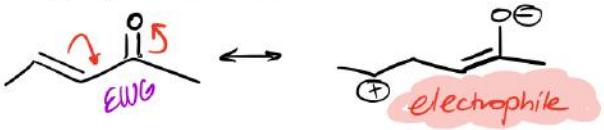
hemiketal

ketal

* Done to protect aldehydes and ketones from reaction with nucleophiles and bases. *

acidic conditions return an acetal and ketal to aldehydes and ketones

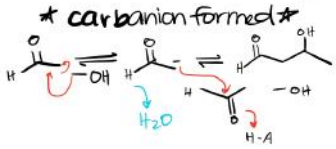
α-β unsaturated carbons

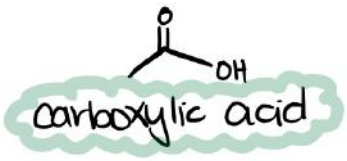


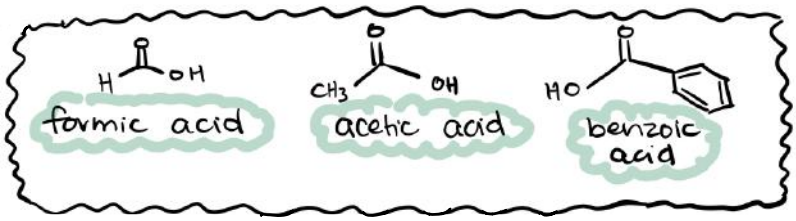
aldol condensation

condensation of an aldehyde with an aldehyde or a ketone with a ketone

* carbanion formed *



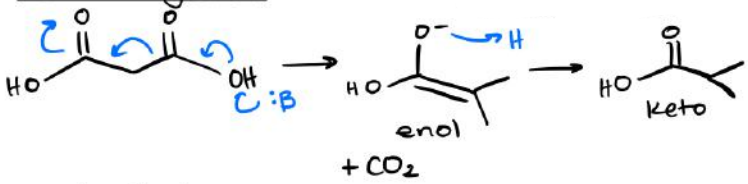




-oic

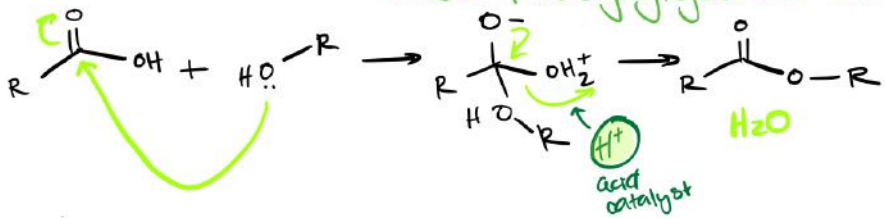
- carbonyl + hydroxyl substitute on alpha carbon
- high boiling points
- resonance stabilized

<u>decarboxylation</u>



<u>esterification</u>

How triacylglycerols are formed

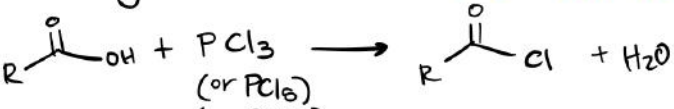


<u>acid chlorides</u>

-oyl chloride

- carbonyl + chloride

Cl- will not form an acid chloride

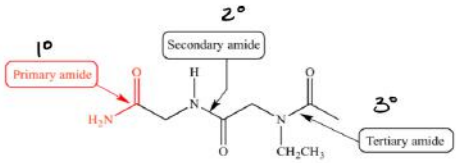


<u>anhydrides</u>

-oic anhydride

- electrophilic

<u>amides</u>



-amide

ie: benzoic acid → benzamide

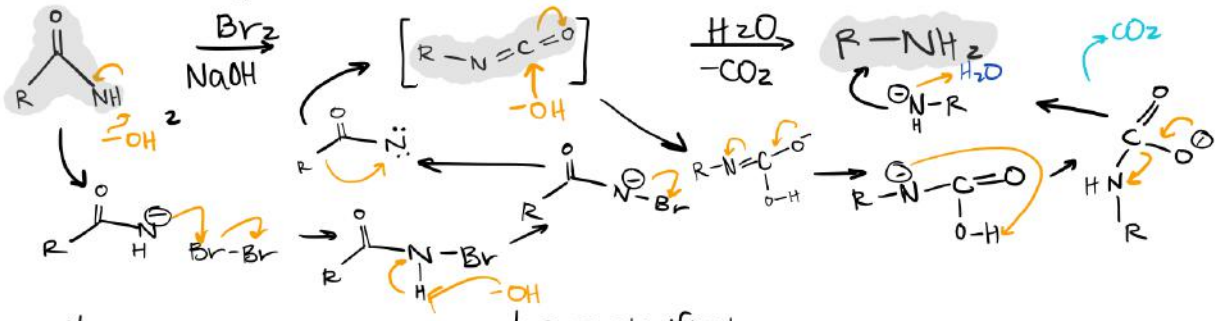
- most stable acid derivative
- carbonyl carbons unreactive (for MCAT)
- 1° and 2° amides can H-bond and are ~water soluble~

3° amides cannot H-bond.

Hoffman Degradation

1° amides react in strong basic solutions of Cl_2 or Br_2 to form 1° amines

★ Decarboxylation ★



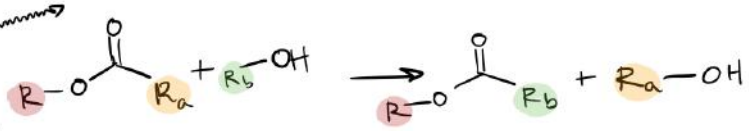
esters

—oate

- H-bond acceptors not H-bond donators

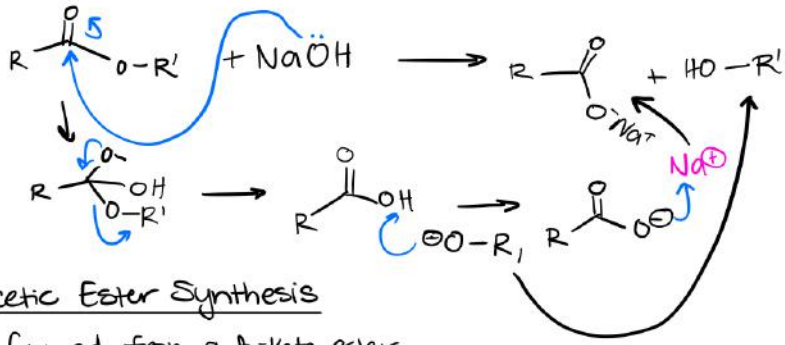
transesterification

ester + alcohol ★ acid catalysis ★



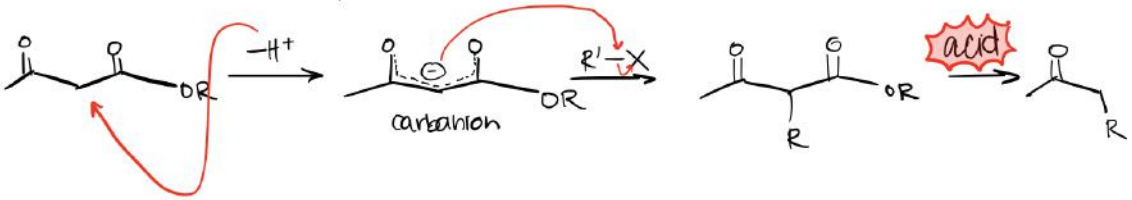
Saponification

ester hydrolysis to an alcohol and salt of carboxylic acid.



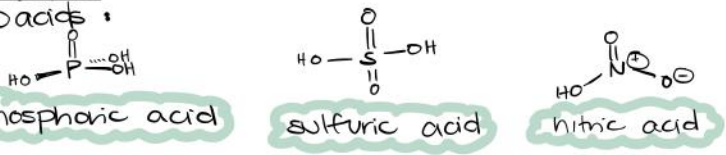
acetoacetic Ester Synthesis

ketone formed from a β-keto ester



Inorganic Esters

γ-oxo acids:



phosphoric acid | sulfuric acid | nitric acid

common inorganic ester examples?

- ATP, GTP, UTP (inorganic triphosphate esters)
- $FADH_2$, NADH (inorganic diphosphate esters)
- FMN, DNA, RNA (monophosphate esters)

acid derivative Leaving Groups

* Goodliest ~~~~~> Crapliest

$-Cl > -OCOR > -OH > -OR > -NH_2$

* Stablest ~~~~~> Not so stablest

amide > ester > carboxylic acid > anhydride > acid chloride

amines

- bases or nucleophiles

1° or 2° = nucleophiles

3° = base

$NH_4^{\oplus}$ electrophiles

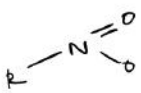
Synthesis of alkyl amines

amine + alkyl halide → alkylamine

$NH_3 + CH_3Br \rightarrow NH_2CH_3 + Br$

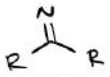
Reduction Synthesis of amines

Reduction of amides, imines, nitriles, and nitro groups:

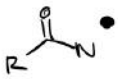


- **nitro groups**: reduced to 1° amine by any reducing agent ($LiAlH_4$, $NaBH_4$, H_2/cat)

- **nitrile groups**: reduced to 1° amine by any reducing agent



- **Imines**: reduced to 1° amine by any reducing agent



- **Amides**: 1° amine only by $LiAlH_4$

adding amines to carbonyls

amines + ketones/aldehydes = imine or enamine

1° amines → imines

2° amines → enamines

3° amine → no rxn