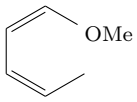
Week 4

Exam 1 Materials

4.1 Office Hours (Snyder)

1/31:

- Sterics vs. an EDG on the diene?



  - Even if you have a strong EDG, if sterics prevents your diene from achieving the s-cis conformation, the reaction will be very slow and/or not proceed.

- PSet 2, 1f: Why is *t*-BuOH listed?
  - We need the Zaitsev product here; we ignore the bulky base — it's just used to favor E2 over S_N2.
- PSet 2, 5b: ?
  - Think Diels-Alder here with the given SM as the dienophile and then ozonolysis.

4.2 Office Hours (Salinas)

- E1 2020, 3b: Distinction between carbons 3 and 6?
  - 3 is shifted higher because it's next to two functional groups, whereas 6 is only next to one functional group.
- E1 2020, 4: Ordering of the last 2/3 steps? Shouldn't we take advantage of the allylic stability to make the process even more selective before hydrogenating?
  - Both are right.
- PSet 2, 1e: Is there reactivity with the alkene that's not next to the EWG in the dienophile?
  - Not enough reactivity to care about.
- PSet 2, 4(i): Is the diene too unreactive?
  - Yes
- PSet 2, 6: Are we using benzoyl peroxide to pull the bromine off the starting material and leave a radical behind at that site? A radical which we can either quench with $H\cdot$ or wind back around to form a ring and then quench?
  - Yes.

4.3 Review

2/1:

- Esters bonded to the diene/dienophile through their single oxygen will be donor groups, but worse than groups like OMe.
  - This is because they *can* push electrons toward the diene/dienophile, but they also have the option to withdraw electrons through resonance.
  - This effect is enough to strongly deactivate a dienophile.
- Substituents that aren't on the double bond count as alkyl groups. Their inductive effect will vary based on other groups further down the chain, but they will have no resonance effects.
- When you have two groups on the diene in the "B" position, the diene will *never* be viable.
- He is going to ask us to use the reactions from last quarter, but not know the mechanisms.
  - Write "magic powder" over your arrow if you forget the reagents.
  - Alkene reactions to know: hydrogenation (H_2 Pd/C), dihydroxylation (OsO_4), ozonolysis (O_3 Me_2S), hydrobromination (HBr), and bromination (Br_2).
- We use both KO^{t}Bu and ^{t}BuOH to establish a buffer, an equilibrium that will allow us to both grab and release a proton.
  - This is not so important for E2 chemistry, but is important for other chemistry.
- MS: para-dimethylbenzene vs. ethylbenzene.
  - For para-dimethylbenzene, we can only lose one methyl group (losing the other would lead to a 2+ ion, which we will not observe). This gives a $m/z = 91$ peak.
  - For ethylbenzene, we can lose just a methyl radical *or* the entire ethyl chain. This gives a $m/z = 91$ *and* a $m/z = 77$ peak.
  - Rule: If you have ortho/meta/para substituents, you can lose *at most one* substituent at a time.
- For ^{13}C NMR, he's not above giving us cyclobutane with a ketone attached.
- If you need to form C–C bonds, that's probably going to be Diels-Alder for this exam.

2/2:

- PSet 1/2 review takeaways.
  - 4°/allylic ^{13}C peaks are higher than 3° peaks.
  - When asked how you can distinguish two molecules based on NMR spectra, answer in terms of the number of peaks/shapes of peaks, not the shift of peaks (that's not generally intuitively characteristic of a molecule).
  - Beware Diels-Alder products drawn with stereochemistry opposite to the way we've practiced.
  - Show the H–$SnBu_3$ bond homolytically cleaving if necessary.

4.4 Exam 1 Cheat Sheet

2/3:

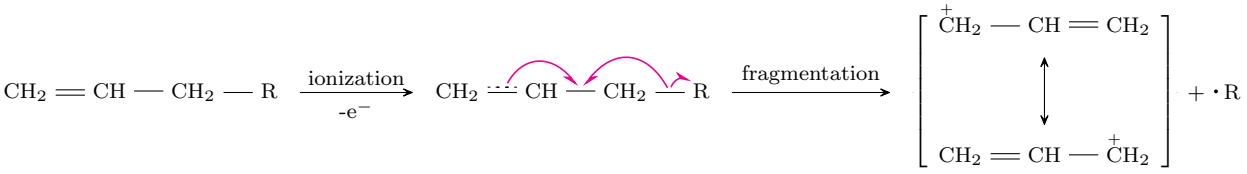
COMMON ABSORPTIONS	
Aromatic C–C	Two peaks usually in the range of $1500 - 1600\,cm^{-1}$
C=C	$\sim 1650\,cm^{-1}$
C=O	$\sim 1710\,cm^{-1}$ (shifts to $\sim 1735\,cm^{-1}$ for esters)
C≡C	$2100 - 2300\,cm^{-1}$
C≡N	$2100 - 2300\,cm^{-1}$
C–H (aldehyde)	Two peaks at $2170\,cm^{-1}$ and $2810\,cm^{-1}$
sp^3 C–H	Just to the right of $3000\,cm^{-1}$
sp^2 C–H	Just to the left of $3000\,cm^{-1}$
sp C–H	$\sim 3300\,cm^{-1}$
N–H	$\sim 3300\,cm^{-1}$ (one peak for –NH–, two peaks for $-NH_2$)
O–H (alcohol)	$\sim 3400\,cm^{-1}$ (a broad, smooth peak)
O–H (acid)	$\sim 2500 - 3500\,cm^{-1}$ (a very broad, ugly [not smooth] peak)

Common IR spectroscopy absorptions.

Type of Proton	Chemical Shift (δ, ppm)	Type of Proton	Chemical Shift (δ, ppm)
1° Alkyl, RCH_3	0.8-1.2	Alkyl bromide, RCH_2Br	3.4-3.6
2° Alkyl, RCH_2R	1.2-1.5	Alkyl chloride, RCH_2Cl	3.6-3.8
3° Alkyl, R_3CH	1.4-1.8	Vinylic, $R_2C{=}CH_2$	4.6-5.0
Allylic, $R_2C{=}CR{-}CH_3$	1.6-1.9	Vinylic, $R_2C{=}CRH$	5.2-5.7
Ketone, $RCOCH_3$	2.1-2.6	Aromatic, ArH	6.0-8.5
Benzylic, $ArCH_3$	2.2-2.5	Aldehyde, RCOH	9.5-10.5
Acetylenic, $RC{\equiv}CH$	2.5-3.1	Alcohol hydroxyl, ROH	0.5-6.0*
Alkyl iodide, RCH_2I	3.1-3.3	Amino, $R{-}NH_2$	1.0-5.0*
Ether, $ROCH_2R$	3.3-3.9	Phenolic, ArOH	4.5-7.7*
Alcohol, $HOCH_2R$	3.3-4.0	Carboxylic, RCOOH	10-13*

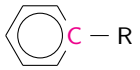
*The chemical shifts of these protons vary in different solvents and with temperature and concentration.

Approximate proton chemical shifts.

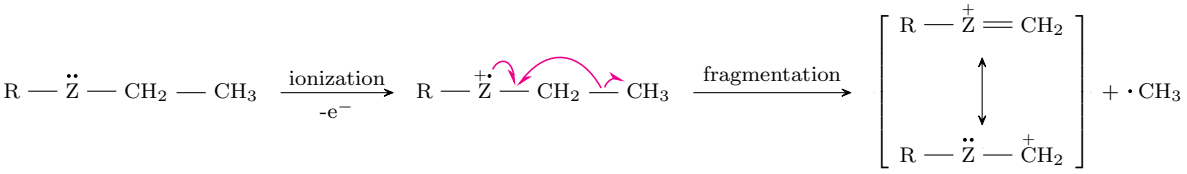


Resonance fragmentation: Alkenes.

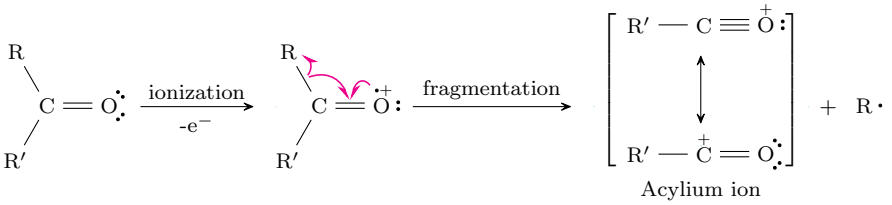
- Alkene reactions to know: hydrogenation (H_2 Pd/C), dihydroxylation (OsO_4), ozonolysis (O_3 Me_2S), hydrobromination (HBr), and bromination (Br_2).

Type of Carbon	Chemical Shift (δ, ppm)
1° Alkyl, RCH_3	0-40
2° Alkyl, RCH_2R	10-50
3° Alkyl, $RCHR_2$	15-50
Alkyl halide or amine, R_3CX (X = Cl, Br, NR'_2)	10-65
Alcohol or ether, R_3COR'	50-90
Alkyne, $RC{\equiv}R'$	60-90
Alkene, $R_2C{=}R'$	100-170
Aryl, 	100-170
Nitrile, $RC{\equiv}N$	120-130
Amide, $RCONR'_2$	150-180
Carboxylic acid or ester, $RCOOR'$	160-185
Aldehyde or ketone, $RCOR'$	182-215

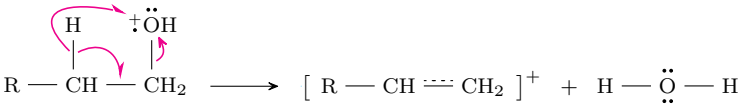
Approximate carbon-13 chemical shifts.



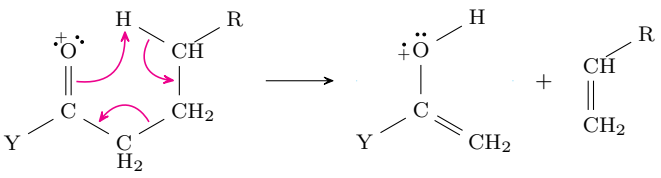
Resonance fragmentation: Lone pairs.



Resonance fragmentation: Carbonyls.



Fragmentation: Loss of H_2O.



Fragmentation: McLafferty rearrangement.