1. (12 min) One of spectra below is for ethyl propiolate, \( \text{H-C} \equiv \text{C} - \text{O} - \text{CH}_2 - \text{CH}_3 \), the other for acetoin, \( \text{CH}_3 - \text{C} - \text{CH} - \text{CH}_3 \). Label each spectrum with the compound name and explain with just a few words every significant PMR peak and the four IR peaks labeled A-D. (E) is given as an example.

(E) alkane C-H stretch, high frequency because H is so light
2. (3 min) Explain what a “normal mode” means in the context of the “fingerprint region” of IR spectra.

3. (9 min) Suggest reagent(s) to achieve each of the following purposes: [Just list reagent(s) - NO mechanism required]
   a) converting an internal alkyne into a cis double bond
   b) converting an internal alkyne to a terminal alkyne
   c) converting a terminal alkyne into a ketone
   d) converting a terminal alkyne into an aldehyde
   e) converting a C=C double bond into a C=O double bond
   f) converting a C=O double bond into a C=C double bond

4. (4 min) Explain why different kinds of magnetic fields are appropriate for chemical NMR and medical MRI.
5. (5 min) Answer A OR B, NOT BOTH

(A) In studying the mechanism of lanosterol biosynthesis using NMR and $^{13}$C double-labeled isopentenyl pyrophosphate, why is it crucial that most of the isopentenyl pyrophosphate not be labeled at all? That is, why was dilute double labeling used?

(B) Explain why this molecule on the right is well suited to be the visual pigment.

6. (7 min) Show the mechanism for acid-catalyzed hydrolysis of the following molecule to 1,2-ethanediol and acetone. Use curved arrows. Several steps are required
7. (10 min) Historically organic chemists speak of “electrophilic” addition of \( \text{CCl}_2 \) to the \( \text{C}=\text{C} \) group of an alkene and “nucleophilic” addition of \( \text{CH}_3\text{Li} \) to the \( \text{C}=\text{O} \) group of a ketone. Draw pictures to explain in terms of the \textit{shapes} of \textit{reagent} HOMOs and LUMOs, and \textit{transition state structures}, how these processes are fundamentally similar.