The exam budgets 50 minutes, but you may have 60 minutes to finish it. Good answers can fit in the space provided. Question values correspond to allotted time. Don't waste too much time on cheap questions.

1. (6 min) Provide an approximate value in kcal/mole for the energy change of the following processes:
   ethylene + H₂ → ethane
   benzene + H₂ → 1,3-cyclohexadiene
   cis-2-butene → trans-2-butene (activation energy without catalysis)
   s-cis-1,3-butadiene → s-trans-1,3-butadiene (activation energy without catalysis)

2. (3 min) The isomeric n-butyl and t-butyl cations differ in energy by 37 kcal/mole in the gas phase. Explain whether you would expect the difference to be larger or smaller in solution.

3. (1 min) Why did Prof. Siegel recommend memorizing the pseudo-word “FONCLBRISCH”?

4. (3 min) If it is possible to add H₂O to an alkene like 3,3-dimethyl-1-butene with simple acid catalysis, why might one choose to use the more complicated, indirect sequence of reaction with Hg(OAc)₂ and water followed by reduction with NaBH₄ to achieve H₂O addition to the alkene?
5. (9 min) Two new bonds to carbons (involving two electron pairs) are formed simultaneously in reaction of \( \text{Cl}_2 \) with ethylene, in reaction of \( \text{BH}_3 \) with ethylene, and in reaction of \( \text{O}_3 \) with ethylene. Position each reagent properly with respect to the ethylenes below (two frames for each reagent; one for each electron pair), draw their relevant LCAO-MOs (with signs and HOMO/LUMO labels) to show how these three reactions are analogous.

Reaction with Cl\(_2\):

![Diagram of Cl\(_2\) reaction]

Reaction with BH\(_3\):

![Diagram of BH\(_3\) reaction]

Reaction with O\(_3\):

![Diagram of O\(_3\) reaction]

6. (2 min) Explain why the hypothetical reagent CH\(_3\)B(CH\(_2\))\(_2\) should not react like O\(_3\) in the reaction of Question 4, even though their dipolar formulae look similar.
7. (8 min) By choosing different reagents 2-butyne can be converted selectively to either isomer of 2-butene.

A. Give the reagent(s) for forming cis-2-butene:

B. Give the reagent(s) for forming trans-2-butene:

C. Draw a mechanistic sequence (curved arrows and all) to explain how ONE of these processes occurs (either A or B).

8. (5 min) Explain how cross-linking natural rubber (by vulcanization) can both keep it from becoming brittle in the cold and from becoming runny when hot.
9. (9 min) Draw a reasonable reaction sequence (with curved arrows) for converting neryl pyrophosphate to β-pinene.

10. (5 min) What is the mechanistic significance of the fact that addition of DCl to 1,3-pentadiene at -78°C gives three times as much of the 1,2- as of the 1,4-addition product? [It might help to draw the reaction intermediate.]