Read all directions very carefully. Write your answer legibly in the designated spaces and **think** about what you are doing. Total number of points is 350. This exam is supposed to have eight (8) pages.

1. For each of the following terms, write a chemical structure that exemplifies it.  

   \[6 \times 7 = 42 \text{ points}\]

   - **Rotaxane**
   - **Good Substrate for Electrophilic Aromatic Substitution**

   - **Dendrimer**
   - **Good Substrate for Conrotatory Electrocyclization**

   - **Radical Clock**
   - **Good dienophile for Diels-Alder rxn**
2. All-cis-cyclononatetraene (shown below) undergoes a spontaneous electrocyclic ring closure at 25 °C to afford a single product. Suggest a structure for this product and construct full orbital correlation diagram that explains its formation. Then, describe an alternative symmetry-allowed electrocyclic reaction that would lead to an isomeric bicyclononatriene (you can do this without a separate orbital correlation diagram). Explain why the product of this alternative reaction is not observed.

80 points
3. Define, in your own words, the following terms. Be succinct but precise. Use chemical formulas if necessary.

**Homoaromaticity**

**Antaracylic**

**Polydispersity Index**

**Exciplex**

**Phosphorescence**

**Catenane**

4. Using qualitative molecular orbital theory, predict the regio- and stereochemical outcome of the following 1,3-dipolar cycloaddition. Show your work.

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+ \text{CN} \quad \xrightarrow{\text{heat}}
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31 points
5. A 1 g sample of a monodisperse polymer with $M = 100,000$ is mixed with 2.5 g of a monodisperse polymer with $M = 200,000$. Calculate the polydispersity index of this mixture.
6. Suggest a mechanism by which each of the following three transformations could occur. More than one step is involved in each case. 

3 \times 20 = 60 \text{ points}
7. Compound A acts as a supramolecular host for methane, with a binding constant of 200 M\(^{-1}\) in (CHCl\(_3\))\(_2\)—a solvent that does not compete with methane for binding. In chloroform, methane binding is weaker, as chloroform acts as a competitive guest for A, with an association constant of 20 M\(^{-1}\). Calculate the apparent binding constant for methane in chloroform solution, assuming that the nature and strength of binding are the same in both solvents. Density of liquid chloroform is 1.48 g cm\(^{-3}\).  

40 points
8. If the following compounds are mixed in an equimolar ratio and subjected to slow dehydration, only four products are formed. Which four products are those? Explain this high selectivity.  

25 points