You are allowed to have scratch paper and a simple model set. You do not need a calculator.

Read each question carefully so that you answer properly.

Please have your ID visible on the adjacent seat.

Make sure answers are clear to receive maximum credit.

Do not second-guess yourself.
1. (5 points) List the requirements for aromaticity:
   
   **A. See pages 537-38.**

   B.

   C.

   D.

2. (5 points) Both of the aromatic compounds below contain nitrogen atoms with lone pairs and can function as a base. Circle which one is less basic (less likely to get protonated) and briefly state why.

   ![Compounds](image.png)

   **See § 12.9.** Lone pair on pyrrole is part of the $4n+2$ $\pi$-system. If protonated, the $\pi$-system becomes $4n \neq 4n+2$ and aromaticity would be lost. Not an issue with pyridine because the lone pair is not part of the aromatic $\pi$-system.

3. (10 points) Use Frost’s circle and electron counting to determine if the following compound is aromatic.

   ![Frost's circle](image.png)

   **Frost’s circle only tells us that aromaticity is possible (no electrons above equator). However, the $\pi$-system only contains $4n \neq 4n+2$ electrons, so not aromatic.**

4. (20 points) Provide a full mechanism for the following transformation (use arrows to move electrons). This should look familiar. Bold parts of molecules are hints to mechanism. Two mechanisms we studied occur in this one reaction.

   ![Mechanism](image.png)

   **See problem 21.31**
5. (20 points) Fill in the boxes with products or reagents. Think activating/deactivating, steric, stoichiometry, and directing. Complete 4 of the following 7. More than 4 is extra credit.

This group is destroyed by acid. Please don't destroy it.
6. (20 points) Provide the missing products or starting materials. Write “no reaction” if there is none. Complete 3 of the following 4. More than 3 is extra credit.

![Chemical reactions and products]

7. (20 points) Provide a reasonable synthesis of the compound below starting from benzene. You know no direct way to attach carboxylic acid groups to a benzene ring. OK, SO SOME OF YOU RECALLED OTHER WAYS TO DO THAT ... NICE!!!

![Chemical reactions and products]

or do F-C alkylation, 2nd step not necessary, but you have to avoid over-alkylation

The above is only one example of multiple ways to do this.