Multiple Choice Questions.  60 points  Select the best answer to each of the questions.

1. Choose the other major product formed in the following reaction.

   \[ \text{OH} \quad \xrightarrow{\text{H-Br}} \quad \text{Br} \quad + \quad ? \]

   ![Reaction products](image)

   A  B  C  D  E

2. Choose the reactants that would give the following Diels-Alder product.

   \[ \text{Diels-Alder reaction} \quad \text{CH}_3 \quad \text{CO}_2\text{Et} \]

   ![Diels-Alder reactants](image)

   A  B  C  D  E

3. Arrange the following bonds in order of increasing C-C bond strength.

   ![Bonds](image)

   i < ii < iii  
   i < iii < ii  
   ii < iii < i  
   iii < ii < i  
   iii < i < ii  

   A  B  C  D  E
4. Choose the compound that is the product of 1,4-addition free radical addition of H-Br to isoprene.

\[
\text{CH}_2=\text{CH}_2 + \text{H}-\text{Br} \rightarrow \text{RO-OR}
\]

A \[\text{CH}_2=\text{CH}_2\text{Br}\] B \[\text{CH}_2=\text{CH}_2\text{H}\] C \[\text{CH}_2=\text{CH}_2\text{Br}\] D \[\text{CH}_2=\text{CH}_2\text{Br}\] E \[\text{Br-CH=CH}_2\]

5. Choose the order that has the following compounds correctly arranged with respect to increasing wavelength of light absorption.

\[
\text{i} \quad \text{ii} \quad \text{iii}
\]

\[
\text{A} \quad \text{B} \quad \text{C} \\
\text{i} < \text{ii} < \text{iii} \\
\text{increasing wavelength}
\]

6. Choose the order that has the following molecular orbitals correctly arranged with respect to increasing energy (least stable MO would be on the right).

\[
\text{i} \quad \text{ii} \quad \text{iii}
\]

\[
\text{A} \quad \text{B} \quad \text{C} \\
\text{i} < \text{ii} < \text{iii} \\
\text{increasing energy}
\]

7. Choose the *aromatic* nitrogen heterocycles.

\[
\text{i} \quad \text{ii} \quad \text{iii}
\]

A. i B. ii C. iii D. i and ii E. i, ii, and iii
8. Choose the *anti aromatic* hydrocarbons.

   i  
   ii 
   iii 

A. i B. ii C. iii D. i and ii E. i, ii and iii

9. Choose the order that has the following compounds correctly arranged with respect to nitration (HNO₃/H₂SO₄)

   i < ii < iii increasing reactivity

A. i ii iii B. ii iii i C. iii i ii D. iii i ii E. i ii iii

10. Choose the best synthesis for the following compound from benzene.

   \[
   \text{C}_6\text{H}_6 \rightarrow \text{C}_6\text{H}_5\text{NO}_2 \\
   \]

   A. 1. HNO₃/H₂SO₄ 2. CH₃CH₂Cl/AlCl₃
   B. 1. HNO₃/H₂SO₄ 2. CH₃COCl/AlCl₃ 3. Zn(Hg), HCl
   C. 1. CH₃COCl/AlCl₃ 2. HNO₃/H₂SO₄
   D. 1. CH₃COCl/AlCl₃ 2. Zn(Hg), HCl 3. HNO₃/H₂SO₄
   E. 1. HNO₃/H₂SO₄

11. Choose the major product of the following reaction sequence.

   \[
   \text{C}_6\text{H}_6 \rightarrow \text{C}_6\text{H}_5\text{Br} \\
   \]

   A. NO₂ B. NO₂ Br C. NO₂ 

12. Choose the most correct statement about the bromination (Br₂/FeBr₃) of methylbenzene (toluene).

   A. Toluene reacts faster than benzene because the methyl group stabilizes the aromatic ring.
   B. Toluene reacts faster than benzene because the methyl group stabilizes the cation intermediate.
   C. Toluene reacts faster with benzene because the methyl group stabilizes the product.
Source

Short Answer Questions. 40 points.

13. (5 pts) Azulene is a blue hydrocarbon obtained from distillates of yarrow. Azulene has the properties of an aromatic compound but, in contrast the isomeric naphthalene, azulene has a significant dipole moment (0.8D). Draw the resonance structure of azulene that best illustrates the dipole moment of azulene and are consistent with our understanding of aromaticity.

![Azulene and Naphthalene Structures]

Predict the major products of the following reactions. Questions 14, 15 and 16.

14. Diels-Alder reaction

![Diels-Alder Reaction Diagram]

15. AlCl₃ reaction

![AlCl₃ Reaction Diagram]

16. Free radical reaction

![Free Radical Reaction Diagram]

17. (10 pts) Starting with benzene and any other compounds containing four carbon atoms or less, give a good synthesis of the following compound. (You may want to use the Diels-Alder and Friedel-Crafts reactions.)

![Synthesis Reaction]

18. (10 pts) Using the curved arrow formalism show the bond making and bond breaking that occur in the following transformation.

![Curved Arrow Transformation]