1. How do alkyl substituents stabilize a carbocationic center to which they are attached?
   (A) Through an inductive donation of electron density to the cationic center.
   (B) Through an inductive removal of electron density from the cationic center.
   (C) Through hyperconjugation.
   (D) both A and C
   (E) both B and C

2. Which of the statements below correctly describes an achiral molecule?
   (A) The molecule has a nonsuperimposable mirror image.
   (B) The molecule exhibits optical activity when it interacts with plane-polarized light.
   (C) The molecule has an enantiomer.
   (D) The molecule might be a meso form.

3. What term describes the structural relationship between cis-1,2-dimethylcyclopentane and trans-1,3-dimethylcyclopentane?
   (A) not isomers
   (B) constitutional isomers
   (C) enantiomers
   (D) diastereomers

4. Which of the following statements applies to the E2 mechanism?
   (A) It occurs with inversion of stereochemistry.
   (B) It occurs with racemization of stereochemistry.
   (C) It proceeds through the more stable carbocation intermediate.
   (D) The C-H and C-X bonds that break must be anti.
   (E) Use of a bulky base gives the more highly substituted alkene product.

5. HBr can be added to an alkene in the presence of peroxides (ROOR). What function does the peroxide serve in this reaction?
   (A) nucleophile
   (B) electrophile
   (C) radical chain initiator
   (D) acid catalyst
   (E) solvent

6. The Williamson ether synthesis proceeds via an _______ mechanism.
   (A) S_N1
   (B) S_N2
   (C) E1
   (D) E2

7. Which of the following reagents is the best choice for oxidizing a primary alcohol to an aldehyde?
   (A) H_2CrO_4
   (B) pyridinium chlorochromate
   (C) Na_2Cr_2O_7, H_2SO_4
   (D) KMnO_4
   (E) LiAlH_4

8. Which of the following terms best describes the reactive nature of a Grignard reagent?
   (A) carbocation
   (B) free radical
   (C) electrophile
   (D) nucleophile
   (E) carbene

9. How many elements of unsaturation are implied by the molecular formula C_5H_5NO_2?
   (A) 0
   (B) 1
   (C) 2
   (D) 3
   (E) 4

10. Which alcohol reacts most rapidly with the Lucas reagent?
    (A) benzyl alcohol
    (B) methanol
    (C) 2-propanol
    (D) isobutanol

11. Which of the following amines is most basic?
    (A) aniline
    (B) N-ethylaniline
    (C) N,N-diethylaniline
    (D) piperidine
    (E) pyrrole
12. When CH₃CH₂CHO reacts with PhNH₂ under conditions of acid catalysis, the major organic product is __________.
   (A) a ketone  (B) a nitrile  (C) an imine  (D) an oxime  (E) a hydrazone

13. Which of the following is most acidic?
   (A) acetone  (B) ethyl acetate  (C) malonic ester  (D) acetoacetic ester  (E) acetaldehyde

14. Which compound has a carbonyl stretch in its IR spectrum at the lowest wavenumber?
   (A) acetic anhydride  (B) formamide  (C) cyclohexanone  (D) propanoyl chloride  (E) ethyl acetate

15. Arrange the carboxylic acid derivatives below in order of increasing reactivity towards nucleophilic acyl substitution

   ![Carboxylic Acid Derivatives](image)

   (A) 1 < 2 < 3  (B) 1 < 3 < 2  (C) 2 < 1 < 3  (D) 2 < 3 < 1  (E) 3 < 2 < 1

16. A reaction under kinetic (or rate) control will yield predominantly:
   (A) the most stable product.
   (B) the product that can be formed in the fewest steps.
   (C) the product whose formation requires the smallest free energy of activation.
   (D) the product with the greatest potential energy.
   (E) the product with the least potential energy.

17. The product, C, of the following reaction sequence is what compound?

   ![Reaction Sequence](image)

   (A) I  (B) II  (C) III  (D) VI  (E) V

18. What would be the product, G, of the following reaction sequence?

   ![Reaction Sequence](image)

   (A) C₆H₅CONH₂  (B) C₆H₅CH₂NH₂  (C) p-CH₃C₆H₄SO₂NH₂
   (D) p-CH₃C₆H₄NH₂  (E) C₆H₅NH₂
19. The product, B, of the following reaction sequence, would be:

(A) I  (B) II  (C) III  (D) VI

20. Arrange these hexadienes in order of expected decreasing stability

(A) V > II > I > III > IV  (B) III > IV > II > I > V  (C) IV > III > II > V > I
(D) IV > III > I > II > V  (E) I > II > IV > III > V

21. The product, E, of the following reaction sequence, would be?

(A) I  (B) II  (C) III  (D) VI  (E) V

22. In electrophilic aromatic substitution reactions a bromine substituent:
(A) In electrophilic aromatic substitution reactions a bromine substituent.
(B) is a deactivator and an o,p-director.
(C) is an activator and a m-director.
(D) is an activator and an o,p-director.
(E) none of the above.
23. Which sequence correctly ranks the following aromatic rings in order of increasing rate of reactivity with chlorine and aluminum chloride

\[
\begin{align*}
1 & : \text{ benzene } \\
2 & : \text{ aniline } \\
3 & : \text{ phenol }
\end{align*}
\]

(A) $1 < 2 < 3$  (B) $2 < 3 < 1$  (C) $3 < 2 < 1$  (D) $2 < 1 < 3$  (E) $1 < 3 < 2$

24. In NMR terminology, protons $H_a$ and $H_b$ are said to be:

- (A) identical  (B) enantiotopic  (C) diastereotopic  (D) homotopic  (E) mesotopic

25. Which reagent will distinguish between propylamine and allylamine?

(A) HONO, 0-5°C  (B) $C_6H_5SO_2Cl/OH$, then $H_3O^+$  (C) NaOH  (D) HCl  (E) Br$_2$/CCl$_4$

II. Provide the structure of major organic product in the following reactions. Pay particular attention to region and stereochemical detail. (2 pts each, 20%)

1. \[
\begin{align*}
\text{pentane} & \quad \text{Hg(OAc)$_2$, CH$_3$OH} \\
& \quad \text{NaBH}_4
\end{align*}
\]

2. \[
\begin{align*}
\text{ethylene} & \quad \text{CN} & \quad \Delta
\end{align*}
\]

3. \[
\text{cyclopentane} & \quad \text{HBr}
\]

4. \[
\text{benzene} & \quad \text{HNO}_3, \text{H}_2\text{SO}_4
\]

5. \[
\begin{align*}
\text{aniline} & \quad \text{CH}_3\text{CH}_2\text{CHCl} & \quad \text{AlCl}_3
\end{align*}
\]

6. \[
\begin{align*}
\text{alkene} & \quad \text{BH}_3\cdot\text{THF} \\
& \quad \text{Hg(OAc)$_2$, HO}^- \\
& \quad \text{PCC} \\
& \quad \text{CH}_3\text{MgBr} \\
& \quad \text{H}_2\text{O}
\end{align*}
\]
III. Give the detailed and stepwise mechanism for the following reaction. (6 pts each, 30%)

1. 

2. 

3. 

4. 

5.