1. (32 points) Circle the letter on the right that corresponds to the answer to each question. There is only one correct answer for each question.

(i) What intermediate is formed in the reaction of toluene with acetyl chloride (CH₃COCl) in the presence of AlCl₃?
   A. a benzyne       B. a benzylic radical       C. a Meisenheimer complex       D. an arenium ion

(ii) Which of the following describes the effect of a trifluoromethyl substituent on electrophilic aromatic substitution reactions of an aromatic ring?

(iii) Which of the following statements is *not* true about aniline?
   I. Aniline is soluble in aqueous acid       J. Aniline can be prepared by reduction of nitrobenzene
   L. The amino group is *ortho/para* directing       K. The amino group is deactivating

(iv) Which of the following is the most reactive in a nucleophilic aromatic substitution reaction?

(v) Which of the following is the most acidic?

(vi) What is the purpose of FeBr₃ in the bromination of benzene?

(vii) Which of the following is not an intermediate in the Friedel-Crafts alkylation of benzene with t-butanol and sulfuric acid?

(viii) What is the product of the following reaction sequence?

   CC. *m*-chloronitrobenzene       DD. 2,4,6-trichloroaniline
   EE. *p*-chboroaniline       FF. chlorobenzene
2. (38 points)

(a) Provide the structure of the major organic product of each of the following reactions (indicate if an o-/p- mixture is expected).

\[
\begin{align*}
\text{KMnO}_4 & \quad \text{NaOH, heat} \\
\text{NaOH} & \quad \text{heat} \\
\text{Br} & \quad \text{heat} \\
\text{NO}_2 & \quad \text{Br}_2 \\
\text{FeBr}_3 & \\
\text{CH}_2\text{Br} & \quad \text{KCN} \\
\end{align*}
\]

(b) Explain the experimental observation that the products in the reaction on the right are formed in roughly equal amounts. Your answer should include a key step in the mechanism that accounts for formation of the two products and one sentence of explanation.
3. (30 points) The following transformations cannot be completed in a single step. Provide a sequence of reactions to perform each transformation, showing the reagents and structures of all isolated synthetic intermediates. The synthesis must use the given starting materials; you may also use any other starting materials with 3 or fewer carbon atoms. You may use any reagents. Do not show mechanisms or the structures of reactive intermediates. Shorter, more efficient syntheses are preferred; overly long or inefficient sequences will lose some credit. If a reaction is likely to give a mixture of o- and p- isomers, just draw the one which you would separate and use in continuing the synthesis.