10) Most acidic Proton?
   a)  
   b)  
   c)  

18) Identify the site of protonation when one equivalent of HCl is added to the following molecule.

   a) Nitrogen 1
   b) Nitrogen 2
   c) Both nitrogens
   d) Neither the compound

20. Which orbital is each lone pair in
   a) sp²  sp²  sp²  sp³
   b) sp³  sp³  sp²  sp³
   c) sp²  p  sp²  sp²
   d) sp²  sp²  p  sp²
Aromatic?

Anti aromatic?

Non-aromatic

**Q6** Which are Aromatic?
- a) BCEG
- b) BCDI
- c) CDG IJ
- d) CDI
- e) CGK

**Q7** Which are Anti-aromatic?
- a) ADEHJ
- b) AHK
- c) FH
- d) Conly
- e) Fonly

**Q8** Which are Non-Aromatic?
- a) ABEGHK
- b) DEFGJK
- c) ABEGHK
- d) ABHI
- e) ABFJK
Which of the following are aromatic?

1) A, B, C  
2) A, B, C, D  
3) A, C, D  
4) A, D  
5) A only

Which of the following are aromatic?
Which two compounds are expected to have the largest dipole moment?

A B C D E

Q3 Which is the most stable resonance contributor for the Chlorination of Phenol?

a) b) c) d)
1) Which of the following structures is the most important contributor to the resonance hybrid formed when anisole undergoes o-bromination?

I. \[ \text{Structure I} \]

II. \[ \text{Structure II} \]

III. \[ \text{Structure III} \]

IV. \[ \text{Structure IV} \]

2) Which of the following structures corresponds to the arenium ion intermediate formed in the RDS for the nitration of benzoic acid?

A) \[ \text{Structure A} \]

B) \[ \text{Structure B} \]

C) \[ \text{Structure C} \]

D) \[ \text{Structure D} \]

E) \[ \text{Structure E} \]

- a) A only
- b) A, C, D
Q7 Which of the following groups is deactivating but ortho/para orienting?
   a) -NO
   b) -OME
   c) -OCOME
   d) -NO2

Q8 Which functional group is deactivating but o/p directing?
   a) -NO  b) -OCH3  c) -NO2

Q8 Which of the following compounds reacts the slowest in electrophilic aromatic substitution?

a)  

b)  

c)  

d)  
Expected order of reactivity of following compounds in $\text{Fe}^3\text{Cl}_3$ chlorination (more reactive > less reactive):

I
\[
\begin{array}{c}
\text{O} \\
\text{C} \\
\text{H}_3 \\
\text{C} \\
\text{H} \\
\end{array}
\]

II
\[
\begin{array}{c}
\text{O} \\
\text{N} \\
\text{C} \\
\text{H}_3 \\
\text{C} \\
\text{H} \\
\end{array}
\]

III
\[
\begin{array}{c}
\text{O} \\
\text{O} \\
\text{C} \\
\text{H}_3 \\
\text{C} \\
\text{H} \\
\end{array}
\]

IV
\[
\begin{array}{c}
\text{O} \\
\text{C} \\
\text{H}_3 \\
\text{C} \\
\text{H} \\
\end{array}
\]

Order of decreasing reactivity:

1. 1
2. 2
3. 3
4. 4

(a) 1 > 2 > 3 > 4
(b) 4 > 3 > 2 > 1
(c) 2 > 1 > 3 > 4
(d) 3 > 1 > 2 > 4

Major product of bromination of 2-nitrobenzenesulfonic acid:
\[
\begin{array}{c}
\text{O} \\
\text{N} \\
\text{H}_3 \\
\text{C} \\
\text{H}_2 \\
\end{array}
\]
1. Predict the major product of the following reaction:

$$\text{CN} \xrightarrow{\text{CH}_3\text{Cl}, \text{AlCl}_3}$$

A. $m$-methyl Benzonitrile
B. $m$-chloro Benzonitrile
C. o-cyanotoluene + p-cyanotoluene
D. benzene nitrile

3. Which will be major products?

$$\text{Br} \xrightarrow{\text{FeBr}_3}$$

A. $\text{Br}$
B. $\text{Br}$
C. $\text{Br}$
D. A + C

4. Which will be produced?

$$\text{conc} \xrightarrow{\text{H}_2\text{SO}_4}$$

A. $\text{SO}_3\text{H}$
B. $\text{HSO}_3$
C. $\text{SO}_3\text{H}$
D. $\text{HSO}_3$
Q7 What is the major product of the following reaction?

\[
\begin{align*}
\text{Br}_3 & \xrightarrow{\text{FeBr}_3} \\
\text{A:} & \\
\text{B:} & \\
\text{C:} & \\
\text{D:} & \\
\end{align*}
\]

Q9 Which of the following groups is deactivating but ortho/para orienting?

a) -NO
b) -Ome
c) -OCOme
d) -NO2

Which functional group is deactivating but o/p directing?

a) -NO  b) -OC(OH)3  c) -NO2
Q8 Which of the following compounds reacts the slowest in electrophilic aromatic substitution?

\[ \text{a} \quad \text{b} \quad \text{c} \quad \text{d} \]

15. Expected order of reactivity of following compounds in E2 chlorination \((\text{C}_2\text{H}_4+\text{FCl}_3)\)?

\( \text{I} \quad \text{II} \quad \text{III} \quad \text{IV} \)

A) \( \text{I} \gg \text{II} > \text{III} > \text{IV} \)
B) \( \text{IV} > \text{III} > \text{II} > \text{I} \)
C) \( \text{III} > \text{I} > \text{IV} > \text{II} \)
D) \( \text{II} > \text{III} > \text{I} > \text{IV} \)
order of decreasing reactivity

1 2 3 4

a) 1 2 3 4 5
b) 4 7 3 7 2

4. Major product of bromination of m-nitrobenzenesulfonic acid?

5. Predict the major product of the following reaction

A. m-methyl Benzonitrile
B. m-chloro Benzonitrile
C. o-cyanotoluene + p-cyanotoluene
D. benzenecynitrile
3. Which will be major products?

\[
\begin{align*}
\text{a)} & \quad \text{b)} \\
\text{c)} & \quad \text{d)} \\
\end{align*}
\]

\[
\begin{align*}
\text{conc} & \quad \text{H}_2\text{SO}_4 \\
\end{align*}
\]

\[
\begin{align*}
a) & \quad \text{b)} \\
\text{c)} & \quad \text{d)} \\
\end{align*}
\]
Q7 What is the major product of the following reaction?

\[
\begin{align*}
\text{A:} & \quad \begin{array}{c}
\text{O} \\
\text{H} \\
\text{H} \\
\text{H} \\
\end{array} \\
\text{B:} & \quad \begin{array}{c}
\text{O} \\
\text{H} \\
\text{H} \\
\text{H} \\
\end{array} \\
\text{C:} & \quad \begin{array}{c}
\text{O} \\
\text{H} \\
\text{H} \\
\text{H} \\
\end{array} \\
\text{D:} & \quad \begin{array}{c}
\text{O} \\
\text{H} \\
\text{H} \\
\text{H} \\
\end{array}
\end{align*}
\]
13) Provide major product of rxn:

$$\text{H}_3\text{C}-\text{C} - \text{O} - \text{C} - \text{OH}_3$$

$$\text{FeCl}_3$$

Q4 What is the product of the synthesis?

1) HONO, ice bath

2) CH$_2$OH

a)

b)

c)
2. 

E$_2$ bromination of para-toluenesulfonic acid followed by heating with 50% sulfuric acid produces ortho-bromotoluene. Which of the following intermediates leads to this product?

![Chemical structures](image1)

A)  
B)  
C)  
D)  

3. When Friedel-Crafts alkylation of benzene is carried out with 1 equiv of tert-butyl chloride, a large amount of para-di tert-butyl benzene is formed along with the mono-substitution product.

Why doesn't the benzene react to give tert-butyl benzene (the mono-substitution product)?

A) The tert-butyl substituent activates the benzene ring to further substitution.
B) Heat is bimolecular, so 2 tert-butyl Cl molecules combine w/ one benzene molecule.
C) The tert-butyl substituent is large enough to favor ortho
D) disubstituted product is favored in equilibrium with the mono-substituted ring.

![Chemical structures](image2)
15) What is one of the products?

\[
\begin{align*}
\text{I:} & \quad \text{OH} & \quad \text{OCH}_3 \\
\text{II:} & \quad \text{N} = \text{N} & \quad \text{O} \\
\text{III:} & \quad \text{CH}_3 \\
\text{IV:} & \quad \text{N} = \text{N} & \quad \text{O} \\
\end{align*}
\]

Most activating

- NH$_2$
- NHR
- NR$_2$
- OH
- OR
- NHCR
- O
- OCR
- R
- Ar
- CH-CHR

Q10 Predict the major product of the following reaction.

\[
\begin{align*}
\text{A:} & \quad 2,2\text{-dinitrobenzonitrile} \\
\text{B:} & \quad 2,3\text{-dinitrobenzonitrile} \\
\text{C:} & \quad 2,4\text{-dinitrobenzonitrile} \\
\text{D:} & \quad 2,6\text{-dinitrobenzonitrile}
\end{align*}
\]
When Friedel-Craft alkylation of benzene is carried out with 1 equiv of tert-butyl chloride, a large amount of para-di-tert-butylbenzene is formed along with the mono-substitution product.

B) Why doesn't all the benzene react to give tert-butyl benzene (the mono-substitution product)?

A) The tert-butyl substituent activates the benzene ring to further substitution
B) The reagent is bifunctional, so 2 tert-butyl (1 molecule) combine with one benzene molecule
C) The tert-butyl substituent is large and fewer are more at the para position
D) Disubstituted product is favored in equilibrium with the mono-substituted ring.

\[
\text{Cl} \quad \text{AlCl}_3 \quad \text{large amount}
\]

E) In the reaction below, nitric acid plays the role of

\[
\text{HNO}_3 \quad \frac{\text{H}_2\text{SO}_4}{\text{Heat}} \quad \text{NO}_2
\]

- a) Acid
- b) Base
- c) Carbocation
- d) Leaving group
Which forms benzene dicarboxylic acid when oxidized with KMnO₄?

a)   

b)   

c)   

d)   

Which functional group is found in O₂O dyes?

a) -N₂O     b) -N₃     c) -N=N-     d) -NO₂
Q14 Which compound is most reactive toward nucleophilic attack?

A:

B:

C:

D:

Most activating
- $\text{NH}_2$
- $\text{NHR}$
- $\text{NR}_2$
- $\text{OH}$
- $\text{OR}$
- $\text{NHCR}$
- $\text{OCR}$
- $\text{R}$
- $\text{H}$
- $\text{Ar}$
- $\text{CH=CHR}$

- $\text{F}$
- $\text{Cl}$
- $\text{Br}$
- $\text{I}$
- $\text{COR}$
- $\text{COH}$
Q14 Which compound is most reactive toward nucleophilic attack?

A:  

B:  

C:  

D:  

Q11 Which product is obtained in the reaction of T with sodium methoxide in methanol?
Which of the following compounds has 3 different sets of structurally equivalent H atoms?

A. \( \text{CH}_3 \text{Br-CH}_2-\text{C}-\text{CH}_2-\text{Br} \)
B. \( \text{CH}_3 \)
C. \( \text{Br} \)
D. \( \text{Br} \)

3. Which dibromide gives:
- 1.2 ppm ( triplet, 3H )
- 2.2 ppm ( quintet, 2H )
- 5.2 ppm ( triplet, 1H )

\( \text{HNMR of C}_{6}H_{8}, \ \text{single sharp signal.} \) 
\( \text{CNMR 2 resonance signals.} \)

A. \( \text{A} \)
B. \( \text{B} \)
C. \( \text{C} \)
D. \( \text{D} \)
An unknown compound has the following:

MS: m/z 102

H NMR: 6 1.4 and 3.9 ppm (both singlets, 3:2)

C NMR: 6 108 and 64.4 ppm

IR: several strong in 1000–1300

![Diagram](image)

2. What is the molecule?
   - IR @ 1750
   - 2 H NMR signals
   - 3 C13 signals @ 218, 34, 18 ppm

![Molecules](image)
What is the molecule?
If this spectrum is from a C6H10O4 compound, which strong absorption at 1680 in IR, structure?

CH2 ↓ CH3 ↑ CH ↑

C6H10O4

2 2 3

2 3

δ 3.9  δ 2.1

A  B  C  D
Using the following reagents in the correct order

conc. HNO₃

KMnO₄, OH⁻, Δ

Br₂, FeBr₃
A) i) \text{Cl, AlCl}_3 \quad \text{ii) HNO}_3, \Delta \quad \text{iii) } \text{xylan}_2 \& \text{Pt cat}

B) i) HNO}_3, \Delta \quad \text{ii) Cl, AlCl}_3 \quad \text{ii) HNO}_3, \Delta \quad \text{iii) } \text{xH}_2 \& \text{Pt cat}

C) Cl, AlCl}_3 \quad \text{ii) HNO}_3, \Delta \quad \text{iii) } \text{xH}_2 \& \text{Pt cat}

D) i) HNO}_3, \Delta \quad \text{ii) Cl, AlCl}_3 \quad \text{iii) } \text{xH}_2 \& \text{Pt cat}

10. Devise the best sequence of rxns to prepare 3, 5- dibromoaniline from nitro benzene.

\[ \text{NO}_2 \quad \text{NH}_2 \]

\[ \text{Br} \quad \text{Br} \]

\[ \text{a) i) H}_2 \text{Pt cat} \quad \text{ii) Br}_2, \text{ether} \]
\[ \text{b) i) excess Br}_2, \text{FeBr}_3 \quad \text{ii) H}_2 \text{Pt cat} \]
\[ \text{c) i) H}_2 \text{Pt cat} \quad \text{ii) } \text{H}_2 \text{SO}_4 \text{ heat} \quad \text{iii) excess HBr} \]
\[ \text{d) i) } \text{H}_2 \text{SO}_4 \text{ heat} \quad \text{ii) excess Br}_2, \text{FeBr}_3 \quad \text{iii) H}_2 \text{Pt cat} \]
Synthesis:

\[
\begin{align*}
\text{A:} & \quad \text{H}_2\text{Pt cat} \quad \text{Br}_2 \text{ ether} \quad \text{NaNNO}_2, \text{HCl} \quad \text{H}_3\text{PO}_2 \\
\text{B:} & \quad 3\text{H}_2\text{Pt cat} \quad \text{NaNNO}_2, \text{HCl} \quad \text{H}_3\text{PO}_2 \quad \text{Br}_2 \text{ ether} \\
\text{C:} & \quad 2\text{Br}_2 \text{ ether} \quad 3\text{H}_2\text{Pt cat} \quad \text{NaNNO}_2, \text{HCl} \quad \text{H}_3\text{PO}_2 \\
\text{D:} & \quad 2\text{Br}_2 \text{ ether} \quad \text{NaNNO}_2, \text{HCl} \quad \text{CuBr}_2, i\text{BuSH}_2, \text{Pt cat}
\end{align*}
\]

Q17 What is the major product of the synthesis?

1. 1eq. 1-bromopropane, \text{AlCl}_3
2. \text{HNO}_3, \text{H}_2\text{SO}_4
3. \text{H}_2, \text{catalyst}
4. \text{HONO}, ice bath
5. \text{CuO}, \text{H}_2\text{O}

A: 

B: 

C: 

D:
Q20 Design the synthesis of the following target molecule starting from Benzene. (Performing a retrosynthetic analysis maybe of great help!!!)

![Chemical structure diagram]

A. H₂SO₄  
B. Cl₂, FeCl₃  
C. HCl  
D. HNO₂  
E. HNO₂, H₂SO₄  
F. HNO₃  
G. HNO₃, H₂SO₄  
H. Cl₂  
I. SO₃, H₂SO₄  
J. CH₃, AlBr₃

The reactions are performed in the order written:

- a) GIJH  
- b) ACFE  
- c) UGIB  
- d) IBJG

Q14. What sequence of reagents can be used to accomplish this reaction?

![Chemical structure diagram]

A. HNO₃, H₂SO₄  
B. H₂SO₄ conc.  
C. Br₂, FeBr₃  
D. H₃O⁺  
E. Sn/HCl  
F. F₂, FeF₃  
G. NaNO₂, HBr, 0°C  
H. HBF₄

- a) CF  
- b) BCFD  
- c) ACCEGH  
- d) CBAGH  
- e) AEGHC