Shown below is the incomplete structure of one of the B-vitamins. All of the atoms, except H, have complete octets. Complete the structure and use it to answer the next three (3) questions. This structure carries a charge.

\[ \text{Inorganic Chemistry} \]

1. What is the hybridization of each of the numbered atoms?

\[ \begin{array}{cccccc}
1 & 2 & 3 & 4 & 5 \\
\text{a)} & \text{sp} & \text{sp}^2 & \text{sp} & \text{sp}^2 & \text{sp} \\
\text{b)} & \text{sp}^2 & \text{sp}^3 & \text{sp}^2 & \text{sp} & \text{sp}^3 \\
\text{c)} & \text{sp}^3 & \text{sp}^2 & \text{sp}^2 & \text{sp}^2 & \text{sp} \\
\text{d)} & \text{sp}^2 & \text{sp}^3 & \text{sp}^2 & \text{sp}^3 & \text{sp}^3 \\
\text{e)} & \text{sp} & \text{sp}^2 & \text{sp}^3 & \text{sp}^3 & \text{sp} \\
\end{array} \]

2. How many \( \pi \) bonds are present in the completed structure?

\[ \begin{array}{c}
a) \ 0 \quad b) \ 1 \quad c) \ 2 \quad d) \ 3 \quad e) \ 4 \\
\end{array} \]

3. What is the formal charge on this molecule?

\[ \begin{array}{c}
a) \ 2^- \quad b) \ 1^- \quad c) \ 1^+ \quad d) \ 2^+ \quad e) \ 3^+ \\
\end{array} \]

4. The following energy diagram corresponds to which of the numbered atoms?

\[ \begin{array}{c}
a) \ 1 \\
b) \ 2 \\
c) \ 3 \\
d) \ 4 \\
e) \ 5 \\
\end{array} \]

5. How many different mono-bromination products are produced in the reaction:

\[ \text{2,3-dimethylpentane} + \text{Br}_2 \xrightarrow{\text{hu}} \text{products} + \text{HBr} \]

\[ \begin{array}{c}
a) \ 2 \quad b) \ 4 \quad c) \ 6 \quad d) \ 8 \quad e) \ 10 \\
\end{array} \]
Use the structure, below, to answer the next two (2) questions

6. Which of the following statements is true about this molecule?

   a) It can have optical isomers but not geometric isomers
   b) It can have geometric isomers but not optical isomers
   c) It can have both optical and geometric isomers
   d) It can have neither optical nor geometric isomers

7. Which of the following functional groups is not present in this structure?

   a) alcohol   b) ketone   c) ester   d) alkene
   e) they are all (a-d) present

Use the five structures below to answer the next three (3) questions.

8. Assuming that all five compounds have comparable molecular weights, predict the order of the relative boiling points, from lowest to highest.

   a) III < IV < V < II < I
   b) IV < III < I < V < II
   c) III < II < V < IV < I
   d) V < I < II < III < IV
   e) IV < III < II < I < V

9. Which of these compounds are structural isomers of each other?

   a) I and II   b) I and III   c) II and III   d) IV and V   e) none of them

10. Which of these would you expect to be least soluble in water?

    a) I   b) II   c) III   d) IV   e) V
Use the mechanism show below to answer the next question

11. Which of the following statements is **false** for this mechanism?

   a) The major product is 3-chloro-2,3-dimethylpentane
   b) I is the intermediate for the major product
   c) The nucleophile in step 1 is the pair of $\pi$ electrons
   d) The proton, $\text{H}^+$, is the catalyst
   e) The electrophile in step 2 is the carbocation

12. What is the IUPAC name of the compound used to form the following polymer?

   a) 2-isopropyl-3-methyl-2-butene
   b) 2,3-dimethyl-2-pentene
   c) 2,3,4-trimethyl-2-pentene
   d) 1,1,3-trimethyl-2-buten e) none of these (a-d) are correct

13. A compound was incorrectly named 2-methyl-3-propyl-4-oxobutane. What is the IUPAC name for this compound?
   (Hint: draw it out)

   a) 2-methyl-4-oxo-3-propylbutane
   b) 2-isopropyl-1-oxopentane
c) 2-isopropylpentanal
d) 3-methyl-1-oxo-2-propylbutane
e) 2-isopropyl-1-pentanone
14. The diol, shown below, can undergo a two step process, a dehydration followed by a hydration reaction. If only major products are formed, which compound (a-e) represents the final product?

\[ \text{OH} \quad \text{H}^+ / \text{dry} \quad \text{H}^+ / \text{H}_2\text{O} \quad \text{product} \]

\[ \text{OH} \quad \text{diene} \]

\[ \text{a)} \quad \text{OH} \quad \text{b)} \quad \text{OH} \quad \text{c)} \quad \text{OH} \]

\[ \text{d)} \quad \text{OH} \quad \text{e)} \quad \text{OH} \]

15. Characterize the compound shown below:

\[
\begin{array}{c}
\text{O} \\
\text{OH}
\end{array}
\]

a) ether  

b) hemi-acetal  

c) hemi-ketal  

d) acetal  

e) ketal

16. Which combination of reagents (I – VI) will convert the reactant completely to the product in a two step process?

\[ \text{O} \quad \text{A} \quad \text{B} \quad \text{OH} \]

\[ \text{I NaBH}_4 \quad \text{II H}^+ (\text{dry}) \quad \text{III H}^+ / \text{H}_2\text{O} \quad \text{IV Cr}_2\text{O}_7^{2-} \quad \text{V LiAlH}_4 \quad \text{VI CH}_3\text{OH/H}^+ \]

\[ \begin{array}{cc}
\text{A} & \text{B} \\
a) & \text{III} \\
b) & \text{IV} \\
c) & \text{III} \\
d) & \text{V} \\
e) & \text{II} \\
\end{array} \]
Use the following compounds (I – VI) and the reagents (a-d) to answer the next four (4) questions.

17. Treatment with which one reagent will convert IV to VI
   a) NaBH₄  b) MnO₄⁻  c) H₂/Pt  d) LiAlH₄  e) none of the reagents (a-d) will allow this reaction to take place

18. Treatment with which one reagent will convert I to VI
   a)  b)  c)  d)  e)

19. Treatment with which one reagent will convert II to III
   a)  b)  c)  d)  e)

20. Treatment with which one reagent will convert V to I
   a)  b)  c)  d)  e)

21. Which of the following represents the most stable product of the hydrogenation of 1,2-dibromocyclohexene?

   a)  b)  c)  d)  e) none of these (a-d) are the correct product
22. Which of the following reactions will not proceed as written?

a) \[
\begin{align*}
\text{CH}_2\text{CH}_2\text{COOH} & + \text{CH}_3\text{CH}_2\text{CH}_2\text{OH} \rightarrow \text{CH}_2\text{CH}_2\text{COOCH}_2\text{CH}_2\text{CH}_3 + \text{H}_2\text{O} \\
\text{H}^+ \text{ (dry)}
\end{align*}
\]

b) \[
\begin{align*}
\text{CH}_2\text{CH}_2\text{COOH} & \rightarrow \text{CH}_3\text{CH}_2\text{COCH}_2\text{CH}_3 + 2\text{CH}_3\text{CH}_2\text{OH} \\
\text{H}^+, \text{H}_2\text{O}
\end{align*}
\]

c) \[
\begin{align*}
\text{CH}_2\text{CH}_2\text{COOH} & + \text{CH}_2\text{CH}_2\text{NCH}_3 \rightarrow \text{CH}_2\text{CH}_2\text{CONCH}_2\text{CH}_3 + \text{H}_2\text{O} \\
\text{activator}
\end{align*}
\]

d) all of them (a-c) will proceed as written

e) none of them (a-c) will proceed as written

Use the structure shown below to answer the next two (2) questions:

23. Which of the following statements describes the starred C-N bond?

a) Free rotation about the C-N bond is hindered due to the bulky alkane groups around the nitrogen

b) Free rotation about the C-N bond is hindered due to the large C=O dipole moment

c) Free rotation about the C-N bond is hindered due to a resonance structure involving a C=N bond

d) Free rotation about the C-N bond is hindered due to the lone pair of electrons on N

e) Free rotation about the C-N bond is not hindered

24. Which compounds were involved in the synthesis of this compound?

a) 2-methylpropanoic acid and diethylamine

b) propanoic acid and ethylamine

c) 3-methylpropanoic acid and ethylmethylamine

d) 2-methylbutanoic acid and ethylamine

e) 2-methylpropanoic acid and ethylmethylamine
25. Which of the following steps of a mechanism shows the correct curved arrow notation to yield the product shown?

a)  

b)  

c)  

d)  

e) none of them (a-d)