1. Which one of the following four schemes (A-D) represents a step in the mechanism of the reaction in the box?

![Chemical structures](image)

2. What is the energy diagram for the reaction shown above in Question 1?

![Energy diagrams](image)

3. What type of mechanism the reaction shown in Question 1 has?

A) S$_1$
B) S$_2$
C) E1
D) E2
4. Which one of the following four schemes (A-D) represents a **step** in the **mechanism** of the reaction in the box?

![Reaction Scheme](image)

5. What type of **mechanism** the reaction shown in **Question 4** has?

A) Radical substitution  
B) Radical addition  
C) Electrophilic addition  
D) S$_1$I

6. What is the structure of an **intermediate** in the reaction shown in **Question 4**?

![Intermediate Structures](image)

7. What is the **rate equation** for the reaction in the box?

![Rate Equation](image)

8. What is the **energy diagram** for the reaction shown above in **Question 7**?

![Energy Diagrams](image)

9. What type of **mechanism** the reaction shown in **Question 7** has?

A) E1  
B) S$_1$I  
C) E2  
D) S$_2$I
10. Which of the following structures represents the **major** resonance contributor of molecule in the box?

![Diagram of structures A, B, C, D]

11. Which of the following structures represents the **major** resonance contributor of molecule in the box?

![Diagram of structures A, B, C, D]

12. Which of the following is **NOT** a resonance structure of the molecule shown in the box?

![Diagram of structures A, B, C, D]

13. What is the IUPAC name of the major **product** for the reaction shown in the box?

![Diagram of reaction with options A, B, C, D]

14. What is the IUPAC name of the major **product** for the reaction shown in the box?

![Diagram of reaction with options A, B, C, D]
15. What is the IUPAC name of the major **product** for the reaction shown in the box?

![Chemical structure](image)

A) cis-3,4-dimethyloxirane  
B) trans-2,3-dimethyloxirane  
C) trans-2,3-dimethyloxirane  
D) cis-2,3-dimethyloxirane

16. What is the main **product** of the reaction shown in the box?

![Chemical structure](image)

A)  
B)  
C) HC=CC(CH_2)_2CH_2OH  
C)

17. What is the IUPAC name of the major **product** for the reaction shown in the box?

![Chemical structure](image)

A) (1S,2S)-1-iodo-2-methylcyclopentane  
B) (1R,2R)-1-iodo-2-methylcyclopentane  
C) (1S,2R)-1-iodo-2-methylcyclopentane  
D) (1R,2S)-1-iodo-2-methylcyclopentane

18. What is the IUPAC name of the major **product** for the reaction shown in the box?

![Chemical structure](image)

A) (2S,3S)-2,3-dichlorobutane  
B) (2R,3S)-2,3-dichlorobutane  
C) (R)-1,2-dichlorobutane  
D) (S)-1,2-dichlorobutane

19. What is the IUPAC name of the major **product** for the reaction shown in the box?

![Chemical structure](image)

A) (Z)-3-methyl-2-hepten-5-ynone  
B) (E)-3-methyl-2-hepten-5-ynone  
C) (Z)-3-methyl-2-octen-6-ynone  
D) (E)-3-methyl-2-octen-6-ynone

20. What is the IUPAC name of the major **product** for the reaction shown in the box?

![Chemical structure](image)

A) cis-2-methylcyclopentanol  
B) trans-2-methylcyclopentanol  
C) 1-methylcyclopentanol  
D) 1-methylcyclopentene
21. What is the IUPAC name of the major product for the reaction shown in the box?

\[ \text{TsO} \quad \overset{\text{SN 2}}{\text{KBr}} \quad \text{H}_3\text{C} \quad \overset{\text{acetonitrile}}{\text{?}} \]

A) cis-1-bromo-4-methylcyclohexane  B) cis-1-bromo-3-methylcyclohexane
C) trans-1-bromo-4-methylcyclohexane  D) trans-1-bromo-3-methylcyclohexane

22. What is the IUPAC name of the major product for the reaction shown in the box?

\[ \text{OH} \quad \overset{\text{H}_2\text{SO}_4}{\text{?}} \quad \text{heat} \]

A) methylenecyclopentane  B) 3-methylcyclopentene
C) 4-methylcyclopentene  D) 1-methylcyclopentene

23. What is the main product of the reaction shown in the box?

\[ \text{Br} \quad \overset{\text{CH}_3\text{ONa}}{\text{CH}_3\text{OH}} \quad \text{?} \]

A) (CH\(_3\))\(_3\)C\(\cdots\)CH\(_3\)
B) (CH\(_3\))\(_3\)C\(\cdots\)CH\(_3\)
C) (CH\(_3\))\(_3\)C\(\cdots\)OCH\(_3\)
D) (CH\(_3\))\(_3\)C\(\cdots\)CH\(_2\)

24. What is the main product of the reaction shown in the box?

\[ \text{OH} \quad \overset{\text{NaH}}{\text{?}} \]

A) \(\cdots\)CH\(_2\)
B) \(\cdots\)Na
C) \(\cdots\)
D) \(\cdots\)O\(_2\)N

25. What is the main product of the reaction shown in the box?

\[ \text{HO\(_\cdots\)OEt} \quad \overset{\text{1) TsCl, pyridine}}{\text{?}} \quad \overset{\text{2) NaCN, DMSO}}{\text{?}} \]

A) TsO\(_\cdots\)OEt  B) HO\(_\cdots\)CN
C) SN 2 NC \(_\cdots\)OEt  D) NC\(_\cdots\)OEt

26. What is the main product of the reaction shown in the box?

\[ \text{CH}_3\text{C\equivCH} \quad \overset{1. \text{BH}_3}{\text{?}} \quad \overset{2. \text{H}_2\text{O}, \text{NaOH, H}_2\text{O}}{\text{hydroboration-oxidation}} \]

A) CH\(_3\)CH\(_2\)CH\(_2\)OH  B) CH\(_3\)CH(OH)CH\(_3\)
C) CH\(_3\)COCH\(_3\)  D) CH\(_3\)CH\(_2\)CHO
27. What alkene when treated with ozone and then with (CH₃)₂S gives the products shown in the box?

HCHO + O=C=O (equal moles each)

A) methylenecyclopentane
B) vinylcyclopentane
C) allylcyclopentane
D) 1-methylcyclopentene

28. What is the IUPAC name of the major product for the reaction shown in the box?

H₃C

1. Na

2. CH₃I

A) trans-1-methoxy-3-methylcyclopentane
B) cis-3-methoxycyclopentanol
C) cis-1-methoxy-3-methylcyclopentane
D) 3-methylcyclopentene

29. Which one of the following compounds is the strongest acid?

A) t-BuOH
B) CH₃CH₂Br
C) CH₃NH₂
D) CH₃CO₂H

30. Which one of the following compounds has the highest solubility in water?

A) Cl

B) OH

C) OCH₃

D) CH₃

31. Which molecule is the best substrate for 1,2 reaction?

A) Br

B) Br

C) Br

D) Br

32. Which one of the following molecules is a meso compound?

A) CH₃

B) CH₃

C) CH₃

D) CH₃

33. Which of the following compounds is the strongest base?

A) NaN(CH₃)
B) NaF
C) NaOEt
D) NaI

34. Which one of the following molecules is chiral?

A) Br

B) *OH

C) CH₃

D) CH₃
35. Which of the following molecules contains two chiral centers?

A)  \[ 
\begin{array}{c}
\text{H} \\
\text{OH} \\
\text{CH}_3 \\
\text{C}=\text{CH}_2
\end{array}
\]  
B)  \[ 
\begin{array}{c}
\text{H}_3\text{C} \\
\text{OH} \\
\text{H} \\
\text{CO}_2\text{H}
\end{array}
\]  
C)  \[ 
\begin{array}{c}
\text{H} \\
\text{OH} \\
\text{H} \\
\text{CH}_2\text{OH}
\end{array}
\]  
D)  \[ 
\begin{array}{c}
\text{CH}_2\text{CO}_2\text{H}
\end{array}
\]

36. Consider the following orders of priority (highest to lowest). Which order is incorrect?

A) \( \text{Cl} > \text{CH}_2\text{CH}_3 > \text{CH}_3 > \text{H} \)  
B) \( \text{Cl} > \text{CH} = \text{CH} > \text{C(CH}_3)_3 > \text{H} \)  
C) \( \text{OH} > \text{CHO} > \text{CH}_2\text{CH}_2\text{OH} > \text{CH}_3 \)  
D) \( \text{NH}_2 > \text{CH}_2\text{SH} > \text{CH}_2\text{OH} > \text{CH}_3 \)

37. Which sequence of reagents can be used for the reaction shown in the box?

[Diagram showing the reagents (1) and (2) and the products]

A) (1) NBS, (2) NaN(CH}_3)_2  
B) (1) HBr, (2) (CH}_3)_2\text{NH}  
C) (1) Br, (2) (CH}_3)_2\text{NH}  
D) (1) HBr, (2) NaNH}_2

38. Which sequence of reagents can be used for the reaction shown in the box?

[Diagram showing the reagents (1) and (2) and the products]

A) (1) HBr, (2) NaSCH}_3  
B) (1) NBS, (2) NaSCH}_3  
C) (1) Br, (2) NaSCH}_3  
D) (1) PBr}_3, (2) NaSCH}_3

39. Which sequence of reagents can be used for the reaction shown in the box?

[Diagram showing the reagents (1), (2), and (3) and the products]

A) (1) Br, (2) NaNH}_2, (3) Na  
B) (1) CH}_3\text{Br}, (2) NH}_3, (3) Na  
C) (1) CH}_3\text{Br}, (2) NaNH}_2, (3) H}_2  
D) (1) NaNH}_2, (2) CH}_3\text{Br}, (3) Na

40. Which sequence of reagents can be used for the reaction shown in the box?

[Diagram showing the reagents (1), (2), and (3) and the products]

A) (1) H}_2\text{PO}_4, (2) O}_3  
B) (1) H}_2\text{SO}_4, (2) Os\text{O}_4  
C) (1) CH}_3\text{CH}_2\text{ONa}, (2) Os\text{O}_4  
D) (1) PCC, (2) H}_2\text{SO}_4
41. Which sequence of reagents can be used for the reaction shown in the box?

(A) (1) TsCl, (2) NaN₃
B) (1) SOCl₂, (2) NaCN
C) (1) TsCl, (2) NH₃
D) (1) PCC, (2) NaN₃

42. Which sequence of reagents can be used for the reaction shown in the box?

A) (1) Br₂, (2) NaCN
B) (1) HBr, (2) NaCN
C) (1) RCO₂H, (2) NaN₃
D) (1) RCO₂H, (2) HC≡C⁻Na⁺

43. Which sequence of reagents can be used for the reaction shown in the box?

A) (1) CH₃CH₂ONa, (2) NaOH, H₂O
B) (1) H₂SO₄, heat, (2) H₂SO₄, H₂O
C) (1) IBX, (2) NaOH, H₂O
D) (1) PCC, (2) H₂SO₄, H₂O

44. Which is the least stable alkene?

A) 2-methyl-2-pentene  B) trans-2-pentene  C) 1-pentene  D) 2,3-dimethyl-2-pentene

45. Arrange the compounds in the box in order of decreasing boiling point.

nonpolar  H-bonding
I) butane  II) 2-chloropropane  III) isopropanol

A) (highest) I > II > III  B) (highest) III > II > I  C) (highest) II > III > I  D) (highest) II > I > III

46. Which of the following represents the order of increasing acidity for compounds the box?

(1) CH₃Br  (2) CH₃CO₂H  (3) CH₃CH₂OH  (4) FCH₂CO₂H  (5) HI

A) 1 (strongest) > 2 > 3 > 5 (weakest)  B) 5 (strongest) > 4 > 2 > 3 > 1 (weakest)
C) 4 (strongest) > 1 > 2 > 3 > 5 (weakest)  D) 5 (strongest) > 1 > 4 > 2 > 3 (weakest)
47. Which species is NOT a Lewis acid?
   A) B(CH₂CH₃)₃  B) BH₃  C) AlH₄⁻  D) AlBr₃

48. Which one of the following structures has the lowest diaxial interactions?

49. Which of the following is a tertiary alcohol?
   A) 3-buten-1-ol  B) (R)-2-methyl-1-butanol  C) (R)-3-buten-2-ol  D) 2-methyl-3-buten-2-ol

50. Which of the following molecules contains both an acid AND an alcohol functional group?
   A) \(\text{CH}_3\text{CCH}_2\text{COOH}\)  B) \(\text{NH}_2\text{CH}_3\text{CHCOOCH}_3\)  C) \(\text{OH}\text{CH}_3\text{CHCOOH}\)  D) \(\text{OH}\text{CH}_3\text{CHCHO}\)

**PLEASE MARK YOUR ANSWERS IN THE APPROPRIATE BOX ON THE BACK OF THE SCANTRON FORM (50 points total):**

**Question 51 (30 pts):** Consider the molecule shown below and answers the following questions. Indicate your answers by marking the appropriate number in boxes 51-60 on the back of the Scantron form (3 pts each).

3. Box 51: Number of \(\sigma\) bonds formed by overlap of \(sp^2\) and \(sp^3\) orbitals
   2. Box 52: Number of \(\pi\) bonds formed by overlap of \(sp\) and \(sp\) orbitals
   1. Box 53: Number of \(\sigma\) bonds formed by overlap of \(sp^2\) and \(sp\) orbitals
   4. Box 54: Number of \(\sigma\) bonds formed by overlap of \(s\) and \(sp^3\) orbitals
   2. Box 55: Number of \(\sigma\) bonds formed by overlap of \(sp^3\) and \(sp^3\) orbitals
   2. Box 56: Number of \(\pi\) bonds formed by overlap of \(sp^2\) and \(sp^2\) orbitals
   1\#. Box 58: Total number of \(\sigma\) bonds
   4. Box 59: Total number of \(\pi\) bonds
   8. Box 60: Total number of non-bonding electrons in this molecule

(Continued on the next page)
Question 52 (20 pts): Please write your answers in boxes 66-70 on the back of the Scantron form. Provide the reagents that give indicated products in high yield (4 pts each):

1. Peroxides (radical addition)

2. \( \text{BH}_3 \), THF

3. \( \text{Cl}_2 \), H₂O

4. \( \text{PC} \) or IβX

5. \( \text{H}_2\text{O}_2 \), NaOH, H₂O

6. CH₂Cl₂