1. Name the following compound. Use the IUPAC system and include the stereochemical designations.

2. For the molecule shown below create the potential energy diagram for rotation about the C3-C4 bond. The conformation shown is the zero degree conformation. Rotate the front carbon in a clockwise direction. Be very careful about relative energies.
3. Which of the following is expected to have the highest boiling point? Which should have the lowest? Answer by letter.

a. Propane-1,3-diamine, H\textsubscript{2}NCH\textsubscript{2}CH\textsubscript{2}CH\textsubscript{2}NH\textsubscript{2}  
b. ethyl-methyl-amine C\textsubscript{2}H\textsubscript{5}NHCH\textsubscript{3}  
c. trimethylamine, (CH\textsubscript{3})\textsubscript{3}N

4. For each of the following equilibria is the value of the equilibrium constant, K, less than one (L) or more than one (M).

\begin{align*}
\text{a} & : \text{CH}_3^+ + \text{NH}_2^- \rightleftharpoons \text{CH}_3\text{NH}_2 \\
\text{b} & : \text{HSO}_4^- + \text{CH}_3\text{O}^- \rightleftharpoons \text{SO}_4^{2-} + \text{CH}_3\text{OH} \\
\text{c} & : \text{NH}_3 + \text{C}_2\text{H}_5\text{O}^- \rightleftharpoons \text{NH}_2^- + \text{C}_2\text{H}_5\text{OH}
\end{align*}

5. An unknown compound, C\textsubscript{8}H\textsubscript{14}, is optically active. It reacts with hydrogen gas to yield a compound of formula C\textsubscript{8}H\textsubscript{18}. Careful distillation of the hydrogenation product yields only one fraction which is identified as \textbf{4-methyl heptane}. Suggest a structure for the original unknown compound consistent with the data presented.

6. A sample of $R$ 2-bromobutane has a specific rotation of 60.0 degrees. It is reacted with an excess of isotopically labeled bromide ion. Exchange of the bromide ion takes place.

\[ \text{R-Br} + \text{Br}^- * \rightleftharpoons \text{R-Br}^* + \text{Br}^- \]

The reaction is stopped after a short period of time. It is found that only 5\% of the bromide has been replaced with labeled bromide.

a) If the reaction proceeded by a simple $\text{SN}1$ mechanism what would be the specific rotation of the product?

b) If the reaction proceeded by a simple $\text{SN}2$ mechanism what would be the specific rotation of the product?

c) The specific rotation is found to be 55.0 degrees. What fraction occurred by a simple $\text{SN}2$ mechanism?
For the following reactions give the missing reactants or products. Show the stereochemistry. Write "NR" if there is no reaction. Put answers on the answer sheet. In some questions you are provided with templates for the answer. Use as many templates as needed. If additional templates are needed use identical structures. If you are unsure about the notation ask the monitor.

7.

1,2,5,6-Tetramethyl-cycloocta-1,5-diene

excess
H₂
catalyst

8.

H₃C

H

H

S_N2
TsCl
NaBr
heat
9. 

\[ C_2H_5CO_2H + CH_3NH_2 \]  
\[ \text{cold} \]

10. 

\[ \text{H} \]
\[ \text{Br} \]
\[ \text{H} \]
\[ \text{CH}_3 \]
\[ \text{C}_2\text{H}_5 \]
\[ \text{OCH}_3 \]
\[ \text{C}_2\text{H}_5 \]
\[ \text{H} \]
\[ \text{H} \]
\[ \text{CH}_3 \]
\[ \text{C}_2\text{H}_5 \]

Complete the structure on the left. Remember the answer must appear on the answer sheet.

11. 

\[ \text{CH}_3\text{CO}_2\text{H} \]
\[ \text{SN}_1 \]

Use templates as needed.
Provide efficient synthesis of the following compounds. You may use any alcohols of four or fewer carbons, any inorganic, and any solvent as starting materials. Additionally you may a product requested in an earlier problem in a later problem even if you were not able to provide a synthesis in the earlier problem.

12. 2,2-dimethylpropane.

13. 1-bromo-2,2-dimethylpropane

14. methyl tert butyl ether, (CH₃)₃C-O-CH₃
For the reactions below sketch the transition state of the rate determining step. Be sure to show relative bond strengths and charges.

15. methane + bromine yielding methyl bromide (heat, gas phase)

16. methane + chlorine yielding methyl chloride (uv, gas phase)

17. methyl bromide + iodide ion yielding methyl iodide (heat, solution)

18. protonated tert butyl alcohol, [(CH₃)₃C-OH₂]⁺, and bromide ion yielding tert butyl bromide, (CH₃)₃C-Br (heat, solution)

For the reactions below will increasing the solvent polarity increase (+), decrease (-), or have little effect (0) on the overall rate of reaction. Answer by symbol +, -, 0.

19. methyl bromide + iodide ion yielding methyl iodide (heat, solution)

20. protonated tert butyl alcohol, [(CH₃)₃C-OH₂]⁺, and bromide ion yielding tert butyl bromide, (CH₃)₃C-Br (heat, solution)
21. Sodium azide, NaN₃, is an explosive material used in automobile airbags. Provide three electron diagrams for the azide ion, N₃⁻. **Circle** the most stable electron diagram.

a                                                                 b                                               c

22. You prepare a mixture of 15 mL of methanol (bp 65 deg) and 15 mL of water (bp 100 deg). You perform a **simple** distillation on the mixture and measure the temperature for each mL of distillate collected. Using a dashed line (- - - -) sketch the results on the graph below. Label it "simple". You repeat the separation but perform a **fractional** distillation this time. Using a solid line, sketch the results on the same graph below. Label it "fractional".
Answer Sheet

Circle the name of recitation instructor Howell  Mollica  Sawwan  Shakya

1 (5)

2. (5)

E

0 180 360

3 (4)

highest

lowest

4 (6)

A

B

C

5 (5)

A

B

C

6 (6)

7 (4)

8 (4)

9 (4)
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1. (3)
R₃⁺ (R = Br, NO₂, H)

2. (5)
E
0  180  360

3. (4)
highest lowest
A  B  C

4. (6)
A  B  C
m  m  L

5. (5)

6. (6)
A  57°  54°
B  57°  54°
C  2/3  2/3

7. (4)
2 2 \text{ for c extra}

8. (4)

9. (4)

\text{config. 2p⁺}

\text{C}_3\text{H}_7\text{CO}_2^- \quad \text{N}_3\text{H}_3\text{CH}_3
12 (4)
\[ \text{tBuOH} \rightarrow \text{tBuBr} \rightarrow \text{LiCux} \rightarrow (t\text{Bu})_2\text{CuLi} \rightarrow \text{CH}_3\text{OH} \rightarrow \text{PBr}_3 \rightarrow \text{C}_2\text{H}_5\text{Br} \]

13 (4)
\[ \text{c} - \text{c} - \text{c} \xrightarrow{\Delta} \text{c} - \text{c} - \text{c} - \text{Br} \]

14 (4)

15 (4)
\[ \text{H}_3\text{C} - \text{H} - \text{Br} \xrightarrow{\text{wR}} \text{str} \]

16 (4)
\[ \text{H}_3\text{C} - \text{H} - \text{Cl} \xrightarrow{\text{same}} \]

17 (4)
\[ \text{I} = \text{Cu} - \text{Br} \]

18 (4)
\[ \text{C}_3\text{H}_7\text{Br} \]

19 (4)
0

20 (4)
0

21 (7)
\[ \begin{align*}
\text{a) } & \ \
\text{b) } & \ \
\text{c) } & \ 
\end{align*} \]

22 (5)

\[ \begin{array}{cccc}
\text{temp} & \text{80} & \text{70} & \text{60} \\
\text{volume of distillate} & \\
\end{array} \]