(30pts) 1. Match the following types of organic compounds in Column A with the structural formulas given in Column B. Place the letter of the correct classification type from Column A in the parenthesis next to the correct structural formula in Column B. Place the correct formula in Column C. Give the correct IUPAC name for as many of the structural formulas as you can in Column D. Bonus (1 point/each). Draw a compound that is an isomer and correctly indicate the type of isomerism in Column E.

<table>
<thead>
<tr>
<th>Column A</th>
<th>Col B</th>
<th>Col C</th>
<th>Col D</th>
<th>Col E</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Alkane</td>
<td>![Structural formula for 3-methyl-2-butanol]</td>
<td></td>
<td>3-methyl-2-butanol</td>
<td></td>
</tr>
<tr>
<td>b. alkene</td>
<td>![Structural formula for 3-methyl-2-pinanamine]</td>
<td></td>
<td>3-methyl-2-pinanamine</td>
<td></td>
</tr>
<tr>
<td>c. alkyne</td>
<td>![Structural formula for 2-methyl-cyclopentanone]</td>
<td></td>
<td>2-methyl-cyclopentanone</td>
<td></td>
</tr>
<tr>
<td>d. cycloalkane</td>
<td>![Structural formula for 2,3-dimethylbutanoic acid]</td>
<td></td>
<td>2,3-dimethylbutanoic acid</td>
<td></td>
</tr>
<tr>
<td>e. aromatic</td>
<td>![Structural formula for 3-hexyne]</td>
<td></td>
<td>3-hexyne</td>
<td></td>
</tr>
<tr>
<td>f. alkylhalide</td>
<td>![Structural formula for ethyl-2-propyl-ether]</td>
<td></td>
<td>ethyl-2-propyl-ether</td>
<td></td>
</tr>
<tr>
<td>g. alcohol</td>
<td>![Structural formula for butyl propanoate]</td>
<td></td>
<td>butyl propanoate</td>
<td></td>
</tr>
<tr>
<td>h. ether</td>
<td>![Structural formula for 2-methyl butanal]</td>
<td></td>
<td>2-methyl butanal</td>
<td></td>
</tr>
<tr>
<td>i. aldehyde</td>
<td>![Structural formula for cis-2-trans-4-hexadiene; trans-2-cis-4-hexadiene]</td>
<td></td>
<td>cis-2-trans-4-hexadiene or trans-2-cis-4-hexadiene</td>
<td></td>
</tr>
<tr>
<td>j. ketone</td>
<td>![Structural formula for toluene or methyl benzene]</td>
<td></td>
<td>toluene or methyl benzene</td>
<td></td>
</tr>
<tr>
<td>k. carboxylic acid</td>
<td>![Structural formula for ]</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>l. ester</td>
<td>![Structural formula for ]</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>m. amine</td>
<td>![Structural formula for ]</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>n. amide</td>
<td>![Structural formula for ]</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>o. amino acid</td>
<td>![Structural formula for ]</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Draw a compound that is an isomer and correctly indicate the type of isomerism in Column E.
(15 pts) 2. We studied four types of organic reactions: substitution (S), addition (A), elimination (E) and condensation (C). Determine the type of each of the following reactions and place the proper letter identifying that type reaction in the parentheses. Bonus: (0.5 bonus point will be awarded for every compound you assign the correct IUPAC name on the line under the compound).

(C)  
\[ \text{butanol} + \text{butanoic acid} \xrightarrow{\text{H}_2\text{SO}_4} \text{butyl butanoate} \]

(A)  
\[ \text{trans-2,trans-4-hexadiene} \xrightarrow{\text{H}_2/\text{Pt}} \text{n-hexane} \]

(C)  
\[ \text{propanol} + \text{propanol} \xrightarrow{\text{NaOH}} \text{dipropyl ether} \]

(S)  
\[ \text{toluene} \xrightarrow{\text{H}_2\text{SO}_4, \text{HNO}_3} \text{2,4,6-trinitrotoluene} \]

(A)  
\[ \text{1-chloroethene} \xrightarrow{\text{catalyst}} \text{polyvinyl chloride (PVC)} \]

(5pts) 3. The five known bases in DNA are Adenine (A), Cytosine (C), Guanine (G), Thymine (T), and Uracil (U). The key to DNA's functioning is its double helical structure with complimentary bases on the two strands.

(a) The chemical structure of the bases enables them to be perfect complimentary base pairs. What chemical phenomena between the base pairs ensures the complimentary base pairs are perfect partners and always are found as pairs on the opposite (complimentary) strands of DNA?

Hydrogen Bonding (either 2 hydrogen bonds or 3 hydrogen bonds depending on the pairs)

(b) Part of a certain DNA sequence is G-G-T-C-T-A-T-A-C, what is the complementary sequence?

look-up base pairs in book
4. The method of initial rates was used to study the following reactions, both reactions were carried out at the same temperature.

a. The first reaction studied was the reaction of bromomethane in a basic (OH⁻) solution, the products are methanol and bromide ions. Draw the structural formula for the reactants and products in a balanced chemical equation.

\[
\begin{align*}
\text{H}_2\text{C} &\text{-Br} + \text{OH}^- \rightarrow 4\text{O} \text{-C} \text{-H} + \text{Br}^- \\
\text{H} &
\end{align*}
\]

Overall reaction:

\[
\begin{align*}
 [\text{CH}_3\text{Br}] \text{ mol/L} &\quad [\text{OH}^-] \text{ mol/L} &\quad \text{Initial Rate, mol/L sec} \\
0.050 &\quad 0.010 &\quad 2.4 \times 10^{-4} \\
0.080 &\quad 0.020 &\quad 7.7 \times 10^{-4} \\
0.080 &\quad 0.010 &\quad 3.8 \times 10^{-4}
\end{align*}
\]

i. What is the actual experimental rate law? Show work

\[
\frac{R_2}{R_1} = \frac{0.0800 \times 0.0100}{0.0500 \times 0.0200} = 1.5 \times 10^3
\]

\[
\text{Initial Rate} = k [\text{CH}_3\text{Br}] \text{ } [\text{OH}^-]^m
\]

\[
\begin{align*}
l &= 1 \\
1.5 \times 10^3 &= k [\text{CH}_3\text{Br}] \text{ } [\text{OH}^-]^m
\end{align*}
\]

\[
\begin{align*}
2 &= (2)^m \\
1 &= (1)^m
\end{align*}
\]

\[
\frac{R_3}{R_2} = \frac{0.0500 \times 0.0100}{0.0800 \times 0.0200} = 1.5 \times 10^{-1}
\]

\[
\text{Initial Rate} = k [\text{CH}_3\text{Br}] \text{ } [\text{OH}^-]^m
\]

\[
\begin{align*}
l &= 1 \\
1.5 \times 10^{-1} &= k [\text{CH}_3\text{Br}] \text{ } [\text{OH}^-]^m
\end{align*}
\]

\[
\begin{align*}
2 &= (2)^m \\
1 &= (1)^m
\end{align*}
\]

ii. What is the value of the specific rate constant? Show work

\[
\frac{R_3}{R_2} = \frac{[\text{CH}_3\text{OH}]}{[\text{Br}^-]} = 1.5 \times 10^{-1}
\]

\[
\text{Rate} = k [\text{CH}_3\text{Br}] [\text{OH}^-]^2
\]

\[
\begin{align*}
l &= 1 \\
1.5 \times 10^{-1} &= k [\text{CH}_3\text{Br}] [\text{OH}^-]^2
\end{align*}
\]

\[
\begin{align*}
l &= 1 \\
1.5 \times 10^{-1} &= k [\text{CH}_3\text{Br}] [\text{OH}^-]^2
\end{align*}
\]

\[
\begin{align*}
4b. &\text{ The second reaction studied was the reaction of 2-bromo-2-methylpropane in a basic (OH⁻) solution, the products are 2methyl-2-propanol and bromide ion. Draw the structural formulas for the reactants and products in a balanced chemical equation.}
\]

\[
\begin{align*}
\text{HO} &\text{-C} \text{-C} \text{-Br} \rightarrow \text{HO} \text{-C} \text{-C} + \text{Br}^- \\
\end{align*}
\]

Overall reaction:

\[
\begin{align*}
 [\text{CH}_3\text{CBr}] &\quad [\text{OH}^-] &\quad \text{Initial Rate, mol/L sec} \\
0.050 &\quad 0.010 &\quad 4.1 \times 10^{-8} \\
0.080 &\quad 0.020 &\quad 6.6 \times 10^{-8} \\
0.080 &\quad 0.010 &\quad 6.6 \times 10^{-8}
\end{align*}
\]

i. What is the actual experimental rate law? Show work

\[
\frac{R_3}{R_2} = \frac{0.0800 \times 0.0100}{0.0500 \times 0.0200} = 1.5 \times 10^3
\]

\[
\text{Initial Rate} = k [\text{CH}_3\text{CBr}] [\text{OH}^-]^m
\]

\[
\begin{align*}
l &= 1 \\
1.5 \times 10^3 &= k [\text{CH}_3\text{CBr}] [\text{OH}^-]^m
\end{align*}
\]

\[
\begin{align*}
2 &= (2)^m \\
1 &= (1)^m
\end{align*}
\]

ii. What is the value of the specific rate constant? Show work

\[
\frac{R_3}{R_2} = \frac{[\text{CH}_3\text{CBr}]}{[\text{Br}^-]} = 1.5 \times 10^{-1}
\]

\[
\text{Rate} = k [\text{CH}_3\text{CBr}] [\text{OH}^-]^2
\]

\[
\begin{align*}
l &= 1 \\
1.5 \times 10^{-1} &= k [\text{CH}_3\text{CBr}] [\text{OH}^-]^2
\end{align*}
\]

\[
\begin{align*}
4c. &\text{ What do these rate studies reveal concerning the two reactions?}
\]

\[
\text{The experimental rate laws are different.}
\]

iii. Do both these reactions appear to proceed by the same mechanism? Explain your answer

\[
\text{No, because the first reaction is second order overall and the second reaction is a first order reaction.}
\]

\[
\text{This implies that the reactions must proceed by different mechanisms because the mechanistic rate law must agree with the experimental rate law in order to be a valid mechanism.}
\]
(10pts) 5. The experimental rate law for the reaction of \(2\text{NO}(g) + \text{O}_2(g) \rightarrow 2\text{NO}_2(g)\) is rate = \(k[\text{NO}]^2[\text{O}_2]\). Four mechanisms have been proposed, which mechanism/s are the best alternatives. Show your work that leads you to your conclusions.

Mechanism 1

\[
\text{Termolecular} \quad 2 \text{NO}(g) + \text{O}_2(g) \rightarrow 2\text{NO}_2(g)
\]

rate = \(k[\text{NO}]^2[\text{O}_2]\)

Mechanism 2

\[
\text{NO}(g) + \text{O}_2(g) \leftrightarrow \text{NO}_3(g)
\]

rate = \(k[\text{NO}]\text{[NO]}\text{[O}_2]\)

Mechanism 3

\[
2 \text{NO}(g) \leftrightarrow \text{N}_2\text{O}_4(g)
\]

rate = \(k[\text{NO}]^2\text{[NO]}\text{[O}_2]\)

Mechanism 4

\[
2\text{NO}(g) \leftrightarrow \text{N}_2\text{O}_3(g) + 2\text{O}_2(g)
\]

rate = \(k[\text{NO}]^2\text{[NO]}\text{[O}_2]\)

Mechanism 2 or 3 would probably be preferred because they do not require a termolecular reaction in the R.D.S.

(10pts) 6. The Arrhenius equation, \(k = Ae^{-\frac{E_a}{RT}}\), relates key factors which define the rate and energetics of a reaction. A more useful representation is

\[\ln k = \ln A - (E_a/R)(1/T)\]

For a given reaction the following data were obtained:

<table>
<thead>
<tr>
<th>T (K)</th>
<th>k (sec(^{-1}))</th>
</tr>
</thead>
<tbody>
<tr>
<td>750</td>
<td>1.8 E-04</td>
</tr>
<tr>
<td>800</td>
<td>2.7 E-03</td>
</tr>
<tr>
<td>850</td>
<td>3.0 E-02</td>
</tr>
<tr>
<td>900</td>
<td>2.6 E-01</td>
</tr>
</tbody>
</table>

one should always use the average over the largest range of temp.

Calculate the activation energy, \(E_a\), over the entire temperature range for the reaction. Show Work

\[
\ln \frac{k_2}{k_1} = \ln A - \frac{E_a}{R}\left(\frac{1}{T_2} - \frac{1}{T_1}\right)
\]

\[
R \ln \frac{k_2}{k_1} = E
\]

\[
\frac{E}{R} = \frac{\frac{1}{T_2} - \frac{1}{T_1}}{\frac{1}{T_2} - \frac{1}{T_1}}
\]

\[
E = -8.314 \times 10^{-3} \text{kJ/molK} \ln\left(\frac{2.6 \times 10^{-1}}{1.8 \times 10^{-4}}\right) \ln\left(\frac{1}{900} - \frac{1}{750}\right)
\]

\[
E = 272 \text{kJ/mol}
\]
(10pts) 7. An analyst has been asked to determine the amount of vitamin C in an unknown sample. First a known solution of vitamin C must be freshly prepared. The known concentration of vitamin C is 0.500 mg/ml. 

Note: a single microburet may be used if the correct wash and clean technique is utilized for this microburet.

Standardization of the 2,6-dichloroindophenol:

Five 5 drop samples of the standard vitamin C were titrated in acidic media with the 2,6-dichloroindophenol.

<table>
<thead>
<tr>
<th>Sample Number</th>
<th>2,6-dichloroindophenol drops</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>15</td>
</tr>
<tr>
<td>2</td>
<td>17</td>
</tr>
<tr>
<td>3</td>
<td>16</td>
</tr>
<tr>
<td>4</td>
<td>14</td>
</tr>
<tr>
<td>5</td>
<td>18</td>
</tr>
</tbody>
</table>

\[ \frac{V_{c} \times C_{c}}{5 \text{ drops} \times 0.500 \text{ mg/ml}} = \frac{\sqrt{\text{V}_{2,6}}}{} \]

\[ \frac{15 + 17 + 16 + 14 + 18}{5} = 16 \text{ drops} \]

(a) What is the average concentration 2,6-dichloroindophenol equivalent to the vitamin C? show work

\[ C_{2,6} = \frac{V_{c} \times C_{c}}{\text{V}_{2,6}} = \frac{(5 \text{ drops})(0.500 \text{ mg/ml})}{16 \text{ drops}} = 0.156 \text{ mg/ml} \]

Unknown Determination:

Five 10 drop samples were taken from 100.0 mL of an unknown juice they were titrated with the standardized 2,6-dichloroindophenol and the following results were obtained.

<table>
<thead>
<tr>
<th>Sample No.</th>
<th>2,6-dichloroindophenol drops</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>25</td>
</tr>
<tr>
<td>2</td>
<td>27</td>
</tr>
<tr>
<td>3</td>
<td>23</td>
</tr>
<tr>
<td>4</td>
<td>24</td>
</tr>
<tr>
<td>5</td>
<td>26</td>
</tr>
</tbody>
</table>

(b) What is the average concentration of vitamin C in the individual samples? Show Work

\[ C_{c} = \frac{\sqrt{\text{V}_{2,6}} \times C_{c}}{V_{c}} = \frac{25 \text{ drops} \times 0.156 \text{ mg}}{10 \text{ drops}} = 0.39 \text{ mg/ml} \]

(c) What is the amount of vitamin C in the 100.0 mL of the unknown juice? Show work

\[ C_{c} \times V_{\text{juice}} = 0.39 \frac{\text{mg}}{\text{ml}} \times 100.0 \text{ ml} = 39 \text{ mg} \]

(d) What % of the RDA does this 100.0 mL sample of juice represent? Show work

\[ \frac{39 \text{ mg}}{60 \text{ mg}} \times 100 \% = 65 \% \text{ of RDA from 100.0 mL sample of juice} \]