Instructions: Show all work whenever a calculation is required! You will receive credit for how you worked each problem as well as for the correct answer. This exam is worth 100 points. BOX YOUR ANSWERS!

1. (6 pts) Circle the substances that are water-soluble?
   - KNO₃
   - CH₃NH₂
   - CaCl₂
   - CH₄
   - H₂S
   - C₂H₅OH

2. (4 pts) The structure of butanol, C₄H₉OH, is shown below. Butanol dissolves in both polar and non-polar solvents. Circle the region of the molecule that accounts for butanol’s solubility in non-polar solvents and draw a box around the part of the molecule that accounts for butanol’s solubility in polar solvents.

3. Xylose has the formula C₅H₁₀O₅ (MM = 150 g/mol). Suppose that 52.3 g xylose was dissolved in 75.0 g water.
   (a) (5 pts) What is the molality?
   (b) (5 pts) What is the mole fraction of xylose?
   (c) (5 pts) What is the mass percent of xylose?

4. (6 pts) What is the mole fraction of magnesium bromide in an aqueous solution that is 0.5578 molal MgBr₂ (MM = 184.3 g/mol)?

5. (6 pts) Aqueous ammonia, NH₃(aq) (MM = 17 g/mol) is sold as a 14.8 M solution with a density known to be 0.90 g/mL. What is the molality of ammonia in this solution?

6. (5 pts) Chloroform has a normal boiling point of 61.7 °C. Its Kᵦ value is 3.63 deg/molal. What is the boiling point of a 0.95 molal solution of naphthalene, a non-volatile solute, in chloroform?

7. (6 pts) Suppose that a solution containing 4.50 g naphthalene was dissolved in 25.0 g chloroform and the resulting solution exhibited a boiling point that was 5.10 degrees higher than that for pure chloroform. What is the MM for naphthalene? Note: Kᵦ value is 3.63 deg/molal.

8. (2 pts) Consider the following aqueous solutions. Circle the solution with the highest expected freezing point. Draw a square around the solution with the lowest expected freezing point.
   A. 0.20 molal C₅H₁₀O₅
   B. 0.20 molal NaCl
   C. 0.20 molal K₂S
   D. 0.20 molal Na₃PO₄
9. In class we studied the kinetics of the reaction below.
(a) (8 pts) Complete the table that follows.

\[ 2 \text{N}_2\text{O}_5(g) \rightarrow 4 \text{NO}_2(g) + \text{O}_2(g) \]

<table>
<thead>
<tr>
<th>Time (s)</th>
<th>[N$_2$O$_5$]</th>
<th>[NO$_2$]</th>
<th>[O$_2$]</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0.0200</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>300</td>
<td>0.0120</td>
<td></td>
<td></td>
</tr>
<tr>
<td>600</td>
<td>0.0072</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(b) (4 pts) Suppose that under certain conditions, it was known that the rate of the reaction was

\[ \text{rate} = -\Delta \left[ \text{N}_2\text{O}_5 \right]/\Delta t = 0.0038 \text{ mol N}_2\text{O}_5/\text{L s}. \]

Under these same conditions, what is the rate in terms of \( \Delta[\text{O}_2]/\Delta t \)?

(c) (3 pts) By doing a time - concentration study on these data, we can determine that the reaction follows first order kinetics. What is the rate law?

(d) (5 pts) Determine the value of the rate constant, \( k \). Be sure to provide the correct units.

(g) (5 pts) What is the predicted rate of the reaction when [N$_2$O$_5$] = 0.073 M?

10. (5 pts) In order to determine the order of a certain reaction (A \( \rightarrow \) B), an initial concentration – initial rate study was conducted yielding the following results: What is the order of the reaction?

<table>
<thead>
<tr>
<th>Initial [A], [A]$_0$ (mol/L)</th>
<th>Initial rate = -\Delta[A]/\Delta t (mol/L min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.038</td>
<td>1.07 x 10$^{-4}$</td>
</tr>
<tr>
<td>0.055</td>
<td>2.24 x 10$^{-4}$</td>
</tr>
<tr>
<td>0.091</td>
<td>6.14 x 10$^{-4}$</td>
</tr>
</tbody>
</table>

11. Consider the following data for the reaction A \( \rightarrow \) B:

(a) (4 pts) What is the order of the reaction? Show work above. Circle: Zero First Second

(b) (2 pts) What is the rate law?

(c) (4 pts) What is the value of the rate constant?

(f) (5 pts) Again using the rate constant that you determined in part (d), determine how long it takes for the concentration to drop from 0.0200 M to 0.0090 M.
Answers
1. Circle KNO₃, CH₃NH₂, CaCl₂, H₂S, C₂H₅OH

2. Circle the C₄H₉ region of the molecule and draw a box around the OH part of the molecule.

3 (a) 4.65 molal
(b) 0.077
(c) 41.1%

4. 0.00994

5. 22.8 molal

6. 65.2 °C

7. MM = 128 g/mol

8. Circle A and box D

9. In class we studied the kinetics of the reaction below.
(a) (8 pts) Complete the table that follows.

\[
2 \text{N}_2\text{O}_5(g) \to 4 \text{NO}_2(g) + \text{O}_2(g)
\]

<table>
<thead>
<tr>
<th>Time (s)</th>
<th>[N₂O₅]</th>
<th>[NO₂]</th>
<th>[O₂]</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0.0200</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>300</td>
<td>0.0120</td>
<td>0.0160</td>
<td>0.0040</td>
</tr>
<tr>
<td>600</td>
<td>0.0072</td>
<td>0.0256</td>
<td>0.0064</td>
</tr>
</tbody>
</table>

(b) \(\text{rate} = -\frac{\Delta \text{[O}_2]}{\Delta t} = 0.0019 \text{ mol O}_2/\text{L s}\)

(c) \(\text{rate} = k[N_2O_5]\)

(d) \(k = 1.70 \times 10^{-3} \text{ s}^{-1}\)

(e) \([N_2O_5] = 0.00971 \text{ M}\)

(f) 469 s

(g) \(\text{rate} = 1.24 \times 10^{-4} \text{ mol/L s}\)

10. second order

11.
(a) Zero
(b) \(\text{rate} = k\)
(c) \(k = 0.0208 \text{ mol/L s}\)