All questions are NOT weighted equally. I have attempted to order the questions from the least difficult to the most difficult, but "beauty is in the eye of the beholder", so skip around to find the problems that are easiest for you. Good luck!

Please print your name in the boxes provided and sign where indicated. Tear off this sheet and pass it to the right for the proctors to pick up.

Print your last name:
Print your first name:

Signature: ________________________________
Problem 1: (25 points) [Oxtoby Problem 10.27] Aspirin is acetylsalicylic acid (H₉C₇H₄O₄), for which $K_a$ is $3.0 \times 10^{-4}$. The molecular weight of acetylsalicylic acid is 180.16 gm/mole. A solution is made by dissolving 0.65 g of acetylsalicylic acid in water and diluting to 50.0 mL.

a) (5 points) What is the (initial) concentration of acetylsalicylic acid in solution before it ionizes and transfers a proton to water? Show all reasoning clearly.
b)(15 points) Calculate the [H$_3$O$^+$] at equilibrium for this solution. (The usual approximate solution gives too large an error to be an acceptable result, so proceed accordingly.) Show all reasoning clearly.


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c)(5 points) Calculate the pH of the solution in part (b). Show all reasoning clearly.

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**Problem 2 (Points 40) [Much in common with Oxtoby problems 13.7, 13.35 and 13.39]**. The following data are measured for the reaction of A with B (dm$^3$ = cubic decimeters):

<table>
<thead>
<tr>
<th>T=300 K:</th>
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</thead>
<tbody>
<tr>
<td>A(mol/dm$^3$)</td>
<td>B(mol/dm$^3$)</td>
<td>Initial Rate $r_0$(mol/dm$^3$ -s)</td>
</tr>
<tr>
<td>2.3x10$^{-4}$</td>
<td>3.1x10$^{-5}$</td>
<td>5.2x10$^{-4}$</td>
</tr>
<tr>
<td>4.6x10$^{-4}$</td>
<td>6.2x10$^{-5}$</td>
<td>4.2x10$^{-3}$</td>
</tr>
<tr>
<td>9.2x10$^{-4}$</td>
<td>6.2x10$^{-5}$</td>
<td>1.7x10$^{-2}$</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>T=310 K:</th>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>A(mol/dm$^3$)</td>
<td>B(mol/dm$^3$)</td>
<td>Initial Rate(mol/dm$^3$ -s)</td>
</tr>
<tr>
<td>2.3x10$^{-4}$</td>
<td>3.1x10$^{-5}$</td>
<td>1.04x10$^{-3}$</td>
</tr>
</tbody>
</table>

a) (10 points) Determine the order of the reaction with respect to species A. Show all reasoning clearly.
b) (10 points) Determine the order of the reaction with respect to species B. Show all reasoning clearly.

c) (5 points) Determine the kinetic rate constant for the reaction of A with B at T=300 K. Show all reasoning clearly.
d) (5 points) Determine the kinetic rate constant for the reaction of A with B at $T=310$ K. Show all reasoning clearly.

e) (10 points) Determine the activation energy for the reaction. Show all reasoning clearly.
Problem 3 (35 points) The graph on the next page shows data (initial rate in units of mM/min vs. substrate concentration in mM=10^{-3} M) for the decomposition of paraoxon by organophosphorus hydrase in foam. This is the same data shown to you in class during our discussion of enzyme kinetics. Dots represent actual data points, and the solid curve through the points is the best fit line to these points. The solid straight line at the top of the graph is the asymptotic limit of the solid curve at infinite substrate concentration. Answer all of the following questions assuming the decomposition of paraoxon substrate by organophosphorus hydrase obeys Michaelis-Menten kinetics. Watch your units carefully!

a)(10 points) Determine the numerical value (including units) of the kinetic rate constant \( k_2 \) if the total enzyme concentration is 5x10^{-6} M. Show all reasoning clearly by using formulas from the free formula sheet.

b)(15 points) What is the numerical value (including units) of \( K_M \), the Michaelis-Menten constant for this system. Show all reasoning clearly using formulas from the free formula sheet.
c)(10 points) If the total enzyme concentration is halved to $2.5 \times 10^{-6}$ M, give the numerical value (including units) for the maximum initial rate at infinite substrate concentration and the value of $K_M$, the Michaelis-Menten constant. Show all reasoning clearly using formulas from the free formula sheet.
Problem 4: (50 Points) [Much in common with Oxtoby problems 10.45, 10.49, 10.54 and 10.55 and the titration recitation exercise.] An unknown student takes an unknown weight of an unknown monobasic weak acid (e.g. HA), dissolves it in an unknown amount of water, and titrates it with a strong base (e.g. sodium hydroxide) of unknown concentration. When she has added 10.00 ml of base she notices that the pH is 5.00. She continues the titration until she reaches the equivalence point for removal of a proton. At this time her buret reads 22.22 ml.

a) (5 points) If M is the unknown molarity of the strong base, determine the initial number of moles of HA before the titration starts in terms of M. Show all reasoning and calculations clearly!
b)(5 points) Again, in terms of M, determine the number of moles of conjugate base, \( A^- \), after the addition of 10.00 ml of strong base. Show all reasoning and calculations clearly!

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c)(10 points) Again, in terms of M, determine the number of moles of HA after the addition of 10.00 ml of strong base. Show all reasoning and calculations clearly!
d)(15 points) What is $K_a$ for the unknown acid? Show all reasoning and calculations clearly!

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e)(15 points) What is the pH at the point where 15.00 ml of base have been added? Show all reasoning and calculations clearly!
The End