Part 1: Answer 4 of the following 5 questions. If you answer more than 4 cross out the one you wish not to be graded. Otherwise only the first 4 will be graded. 9 points each.

1. For the reaction mechanism $A \rightarrow B \rightarrow C$ can you always use the steady-state approximation, or if not, what must be true?

2. Thermal conductivity can be expressed as a linear flux-force relationship:

$$J_q = -\kappa \frac{dT}{dx}$$

where $\kappa$ is the thermal conductivity. A thermopane window is constructed from two sheets of glass with a narrow spacing. Calculate the thermal flux in a thermopane window with a spacing of 2.00 mm between the panes of glass. Assume the outside air temperature is 0.0°C and the inside is 20.0°C. The thermal conductivity is 0.0252 J m$^{-1}$ K$^{-1}$ s$^{-1}$ at 15°C and 1 atm. Assume a linear temperature gradient.

3. Calculate the pressure inside your mouth that would be necessary to drink a soft drink through a straw of length 20.0 cm. Assume the drink has the density of water at 20.0°C, 0.9982 g mL$^{-1}$ and the atmospheric pressure is 1.000 bar.
4. A substance with a molar absorption coefficient of 12,144 M$^{-1}$ cm$^{-1}$ and a concentration of 2.33x10$^{-6}$ M is found in a lake. Calculate the fraction of the light incident at the surface of the lake that remains at a depth of 1.00 m.

5. A photovoltaic panel can convert at best 12% of the light flux into DC electrical power. The conversion of the DC power from a solar panel to AC power that can be used to power appliances or to feed into the power grid is about 77% efficient. The yearly average insolation for Boston is 4.16 kWh m$^{-2}$ day$^{-1}$. Calculate the AC power available per square meter from photovoltaic cells operating at 12% efficiency in Boston. Express your results in joules per second and also watts. [Hint: 1 kWh = 3.6x10$^6$ J]

**Part 2:** Answer 4 of the following 6 questions. If you answer more than 4 cross out the ones you wish not to be graded. Otherwise only the first 4 will be graded. 16 points each.

6. The rate constant for the decomposition of a certain substance is 2.80x10$^{-3}$ L mol$^{-1}$ s$^{-1}$ at 30.0$^\circ$C and 1.38x10$^{-2}$ L mol$^{-1}$ s$^{-1}$ at 50.0$^\circ$C. Calculate the activation energy and pre-exponential factor.
7. The following mechanism has been proposed for an enzyme reaction with two substrates, A and B:

\[ \begin{align*}
E + A & \overset{k_1}{\underset{k_2}{\rightleftharpoons}} EA \\
EA + B & \rightarrow EAB + Y \\
EAB & \rightarrow E + P
\end{align*} \]

where EA and EAB are enzyme substrate complexes. Assuming that \( k_2 \) and \( k_3 \) are large compared to \( k_1 \), show that the mechanism gives the rate law:

\[
\frac{d[P]}{dt} = \frac{k_1 k_2 [E][A][B]}{k_1 + k_2 [B]}
\]

8. Find the integrated rate law for a third-order reaction with stoichiometry A \( \rightarrow \) B and rate law \(- \frac{d[A]}{dt} = k_3 [A]^3\). (Give the linearized form, for example for a second order reaction the linear form of the integrated rate law is \( 1/[A] - 1/[A]_o = k_2 t \)
9. The *cis-trans* isomerization of 1-ethyl-2-methylcyclopropane is first order in the forward and reverse directions:

\[
\begin{array}{c|c|c}
\text{cis} & k_1 & \text{trans} \\
\hline
\text{cis} & k_1 & \text{trans} \\
\end{array}
\]

<table>
<thead>
<tr>
<th>t (s)</th>
<th>[cis] (M)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0.01679</td>
</tr>
<tr>
<td>1000</td>
<td>0.01102</td>
</tr>
</tbody>
</table>

The reaction, starting with only *cis* isomer has the time course given in the table, above. The long-time value for the *cis*-isomer concentration is 0.00443 M. Determine \((k_1 + k_{-1})\).

10. Consider a reaction with the stoichiometry: \(A + B \rightarrow C + D\). Assume that both A and B absorb at a specific wavelength, while C and D do not. Assume also that A is the limiting reagent, \([A]_o < [B]_o\). Remember that the concentration of A is determined by the extent of the reaction: \([A] = [A]_o - \xi\). Assume that the absorbance of the mixture is the sum of the absorbances: \(A = \varepsilon_A [A] + \varepsilon_B [B]\), where \(\varepsilon_A\) and \(\varepsilon_B\) are the molar extinction coefficients of A and B, respectively. Show that:

\[
\frac{[A]}{[A]_o} = \frac{[A]_o - \xi}{[A]_o} = \frac{A - A_\infty}{A_\infty - A_\infty}
\]
11. Solve the matrix equation \( \begin{pmatrix} 4 & 1 \\ 1 & 0.5 \end{pmatrix} \begin{pmatrix} x \\ y \end{pmatrix} = \begin{pmatrix} 2 \\ 1 \end{pmatrix} \) for \( x \) and \( y \).

\[
\begin{bmatrix}
\text{Hint: } (M_{11} M_{12})^{-1} = \frac{1}{|M|} \begin{pmatrix}
M_{22} & -M_{12} \\
-M_{21} & M_{11}
\end{pmatrix}
\end{bmatrix}
\]