MULTIPLE CHOICE

1. For the reaction: $2\text{ClO}_2\text{(aq)} + 2\text{OH}^-\text{(aq)} \rightarrow \text{ClO}_3^-\text{(aq)} + \text{ClO}_2^-\text{(aq)} + \text{H}_2\text{O(l)}$

<table>
<thead>
<tr>
<th>Experiment</th>
<th>[$\text{ClO}_2$]</th>
<th>[$\text{OH}^-$]</th>
<th>initial rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.060 M</td>
<td>0.030 M</td>
<td>0.0248 M/s</td>
</tr>
<tr>
<td>2</td>
<td>0.020 M</td>
<td>0.030 M</td>
<td>0.00276</td>
</tr>
<tr>
<td>3</td>
<td>0.020 M</td>
<td>0.090 M</td>
<td>0.00828</td>
</tr>
</tbody>
</table>

What is the order of the reaction with respect to $\text{ClO}_2$?

a) 0  
b) 1  
c) 2  
d) 3  
e) 4

2. Which one of the following graphs shows the correct relationship between concentration and time for a reaction that is second order in [$A$]?

a)  
b)  
c)  
d)  
e)  

3. Photoionization processes remove UV of $<150$ nm. Which photoreaction is the principal absorber of UV in the 150-200 nm range in the upper atmosphere?

a) $\text{N}_2 + \text{e}^- + \nu \rightarrow \text{N}_2^-$  
b) $\text{O}_2 + \nu \rightarrow 2\text{O}$  
c) $\text{O}_3 + \nu \rightarrow \text{O}_2 + \text{O}$  
d) $\text{N}_2 + \text{O}_2 + \nu \rightarrow 2\text{NO}$  
e) $\text{NO}_2 + \nu \rightarrow \text{NO} + \text{O}$
4. Why is carbon monoxide toxic?
   a) It causes renal failure.
   b) It binds to hemoglobin, thus blocking the transport of oxygen.
   c) It blocks acetylcholine receptor sites causing paralysis and rapid death.
   d) It induces leukemia.
   e) It binds to oxygen and causes suffocation.

5. How does lime reduce sulfur dioxide emissions from the burning of coal?
   a) It reacts with the sulfur dioxide to form calcium sulfite solid that can be precipitated.
   b) It reduces the sulfur dioxide to elemental sulfur that is harmless to the environment.
   c) It oxidizes the sulfur dioxide to tetrathionate that is highly water soluble so it can be scrubbed from the emission gases.
   d) It catalyzes the conversion of sulfur dioxide to sulfur trioxide which is much less volatile and can be removed by condensation.
   e) It converts SO$_2$ to solid, elemental sulfur.

**FREE RESPONSE:** Show all of your work for each problem. Be extremely complete and organized with your calculations and steps taken to solve the problem.

6. The creation of photochemical smog from internal combustion engines follows the reaction mechanism pathway shown below.
   A) Find the overall reaction equation. (3 points)
   B) Determine the reaction rate law for the overall chemical equation in terms of the reactants in the overall equation. (7 points)
   C) What time of year is the production of smog the greatest? Why? (3 points)
   D) What species gives smog its brown color? Why is it hard to see this color during the winter months? (3 points)

   (1) $N_2(g) + O_2(g) \xrightleftharpoons[k_{-1}]{k_1} 2NO(g)$ (fast)
   (2) $2NO(g) + O_2(g) \xrightleftharpoons[k_{-2}]{k_2} 2NO_2(g)$ (fast)
   (3) $NO_2(g) + h\nu \xrightarrow[k_1]{k_3} NO(g) + O(g)$ (slow)
   (4) $O(g) + O_2(g) \xrightleftharpoons[k_{-4}]{k_4} O_3^+(g)$ (fast)

7. Cyclobutane, C$_4$H$_8$, decomposes when heated to give ethylene. The reaction is first order. In an experiment, the initial concentration of cyclobutane was 0.00150 M. After heating at 450 °C for 455 sec., this was reduced to 0.00119 M. What was the concentration of cyclobutane after a total of 750 sec.? (8 points)