Show your work on numerical problems.

1. (7 points) Consider the following initial rate data collected in the determination of the rate law for the reaction:

\[ 2 \text{A(aq)} + \text{B(aq)} \rightarrow \text{A}_2\text{B} \text{(aq)} \]

<table>
<thead>
<tr>
<th>Experiment #</th>
<th>[A] (M)</th>
<th>[B] (M)</th>
<th>Initial Rate (M/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.10</td>
<td>0.20</td>
<td>(4.0 \times 10^{-2})</td>
</tr>
<tr>
<td>2</td>
<td>0.30</td>
<td>0.20</td>
<td>(3.6 \times 10^{-1})</td>
</tr>
<tr>
<td>3</td>
<td>0.10</td>
<td>0.05</td>
<td>(1.0 \times 10^{-2})</td>
</tr>
</tbody>
</table>

a. Write the rate law for the reaction including the orders.
\[ [\text{A}]: \text{between } 1, 2 \text{ triples, B constant, } \text{rate} \times 9 \text{ so } 3 \leq 9 \Rightarrow 2 \]
\[ [\text{B}]: \text{between } 3, 4 \text{ quadruplets, A constant, } \text{rate} \times 4 \Rightarrow 4 \]

\[ \text{rate} = k \left[ \frac{[A]^2 [B]}{1} \right] \]

b. Give the rate constant for the reaction with the correct units.
\[ k = \frac{\text{rate}}{\left[ \frac{[A]^2 [B]}{1} \right]} = \frac{4.6 \times 10^{-2} \text{ M/s}}{0.10^2 \cdot 0.20} = 20 \text{ M}^{-2} \text{ s}^{-1} \]

c. What is the rate of change of the concentration of component A initially in Experiment #1?
\[ \text{rate} = -\frac{\Delta [A]}{\Delta t} \]

\[ \frac{\Delta [A]}{\Delta t} = -2 \cdot \text{rate} = -2 \left(4.6 \times 10^{-2} \text{ M/s}\right) = -9.2 \times 10^{-2} \text{ M/s} \]

OR, it just gets used up twice as fast as the rate.
2. (9 points) A reaction is first order in reactant A with a rate constant of $2.45 \times 10^{-5}$ M/s.

a. How many seconds would it take for the concentration of reactant A to drop from 0.25 M to 0.15 M?

$$\ln \frac{[A]_t}{[A]_0} = -kt$$

$$\ln \frac{15}{23} = -\left(2.45 \times 10^{-5}\right) t$$

$$t = 209 s$$

b. What is the half-life of the reaction?

$$t_\frac{1}{2} = \frac{\ln 2}{k} = \frac{6.93}{2.45 \times 10^{-5}} = 282 s$$

c. If the concentration of A is initially 0.35 M, how much A would be left after 10 minutes?

$$\ln \frac{[A]_t}{[A]_0} = -(2.45 \times 10^{-5})(10 \times 60)$$

$$[A]_t = 0.080 M$$

3. (9 points) A reaction is second order in reactant A. It takes 5.0 minutes for the concentration of A to drop from 0.35 M to 0.20 M.

a. What is the rate constant for the reaction (include units using seconds for the unit of time)?

$$t_\frac{1}{2} = \frac{1}{k[A]_0}$$

$$k = \frac{1}{t_\frac{1}{2} [A]_0} = \frac{1}{0.5 \times 0.20} = 7.1 \times 10^{-3} M^{-1} s^{-1}$$

b. What is the half-life of the reaction starting from the initial concentration of 0.35 M?

$$t_\frac{1}{2} = \frac{1}{k[A]_0} = \frac{1}{7.1 \times 10^{-3} \times 0.35} \approx 400 s$$

c. Starting from a reactant concentration of 0.35 M, what is the remaining concentration after 225 s?

$$\frac{1}{[A]_t} = -kt + \frac{1}{[A]_0} = (7.1 \times 10^{-3} M^{-1}) (225) + \frac{1}{0.35} = 4.45 M^{-1}$$

$$[A]_t = \frac{1}{4.45 M^{-1}} = 0.22 M$$