Begin your response to **QUESTION 5** on this page.

5. The following equation represents the decomposition of N_2O_5, for which the rate law is rate = $k[N_2O_5]$.

$$2\ N_2O_5(g) \rightarrow 4\ NO_2(g) + O_2(g)$$

A sample of pure $N_2O_5(g)$ is placed in an evacuated container and allowed to decompose at a constant temperature of 300 K. The concentration of $N_2O_5(g)$ in the container is measured over a period of time, and the measurements are recorded in the following table.

Time (hr)	$[N_2O_5]\,(M)$
0	0.160
1.67	0.0800
3.33	0.0400
5.00	0.0200

(a) Determine the value of the rate constant, k, for the reaction. Include units in your answer.

(b) The following mechanism is proposed for the decomposition of $N_2O_5(g)$.

Step 1: $N_2O_5(g) \rightarrow NO_2(g) + NO_3(g)$
Step 2: $NO_2(g) + NO_3(g) \rightarrow NO_2(g) + NO(g) + O_2(g)$
Step 3: $N_2O_5(g) + NO(g) \rightarrow 3\ NO_2(g)$

Identify which step of the proposed mechanism (1, 2, or 3) is the rate-determining step. Justify your answer in terms of the rate law given.

GO ON TO THE NEXT PAGE.

Continue your response to **QUESTION 5** on this page.

(c) If this experiment was repeated at the same temperature but with twice the initial concentration of N_2O_5, would the value of k increase, decrease, or remain the same? Explain your reasoning.

GO ON TO THE NEXT PAGE.

Question 5: Short Answer — 4 points

(a) For the correct calculated value: **1 point**

Accept one of the following:

- $k = \frac{0.693}{t_{1/2}} = \frac{0.693}{1.67\ \text{hr}} = 0.415\ \text{hr}^{-1}$
- $k = \frac{\ln[\text{A}]_0 - \ln[\text{A}]_t}{t} = \frac{\ln(0.160) - \ln(0.0800)}{1.67\ \text{hr}} = 0.415\ \text{hr}^{-1}$
- $k = \frac{\ln[\text{A}]_0 - \ln[\text{A}]_t}{t} = \frac{\ln(0.160) - \ln(0.0400)}{3.33\ \text{hr}} = 0.416\ \text{hr}^{-1}$
- $k = \frac{\ln[\text{A}]_0 - \ln[\text{A}]_t}{t} = \frac{\ln(0.160) - \ln(0.0200)}{5.00\ \text{hr}} = 0.416\ \text{hr}^{-1}$

For the correct units, consistent with the calculated value: **1 point**

hr^{-1}

Total for part (a) 2 points

(b) For the correct answer and a valid justification: **1 point**

Step 1 is the rate-determining step. The rate law of elementary step 1 is $\text{rate} = k[\text{N}_2\text{O}_5]$, *which is consistent with the first order kinetics of the overall rate law.*

(c) For the correct answer: **1 point**

Remain the same. The rate constant, k, is independent of concentration and will remain the same at constant temperature.

Total for question 5 4 points