Kinetics I Quiz **Name:** Key

May I post your solution? [ ] Yes [ ] No [ ] Yes, but redact my name

Consider the following rate data for the reaction: **A + B → C**

Experiment	$[A]_o$ (M)	$[B]_o$ (M)	Initial Rate (M/s)
1	0.100	0.200	0.001762
2	0.100	0.400	0.003524
3	0.400	0.200	0.001762

Determine the value of the rate constant (k) for this reaction, including the units.

Recall that the rate law can be expressed as

$$\text{Rate} = k[\text{A}]^a[\text{B}]^b$$

where k is the rate constant, [A] and [B] are the concentrations of reactants A and B, and a and b are the orders of the reactions with respects to reactant A or B, respectively. The orders tell us, quantitatively, how much the reaction rate is affected by the concentration of a reactant, so larger orders indicate greater effects.

To determine the orders a and b, we can use what is referred to as the "isolation method," in which we compare two experiments where only one reactant's concentration is changing. This method allows us to determine how that one reactant affects the reaction rate in isolation.

Let's start with experiments 1 and 2, where we keep [A] constant and vary [B]. Setting up a ratio, we can see:

$$\frac{\text{Rate}_2}{\text{Rate}_1} = \frac{k[\text{A}]_2^a[\text{B}]_2^b}{k[\text{A}]_1^a[\text{B}]_1^b}$$

Now, since k is a constant and $[\text{A}]_2^b = [\text{A}]_1^b$, we can cancel both out. What we are left with then is an expression depending on just [B] and its order, b.

$$\frac{0.003524\,\frac{\text{M}}{\text{s}}}{0.001762\,\frac{\text{M}}{\text{s}}} = \frac{(0.400\text{ M})^b}{(0.200\text{ M})^b}$$
$$2 = 2^b$$
$$b = 1$$

Most often you can deduce the value of the exponent or order by inspection. Mathematically though:

$$2 = 2^b$$
$$\log(2) = b \cdot \log(2)$$
$$b = 1$$

Now, we do the same, but choose experiments 1 and 3, which keep [B] constant but vary [A].

$$\frac{\text{Rate}_3}{\text{Rate}_1} = \frac{k[\text{A}]_3^a[\text{B}]_3^b}{k[\text{A}]_1^a[\text{B}]_1^b}$$
$$\frac{0.001762\,\frac{\text{M}}{\text{s}}}{0.001762\,\frac{\text{M}}{\text{s}}} = \frac{(0.400\text{ M})^a}{(0.100\text{ M})^a}$$
$$1 = 4^a$$
$$a = 0$$

Recall that any number raised to the zero power is equal to 1.

Combing these values of a and b into our rate law above gives:

$$\text{Rate} = k[\text{A}]^0[\text{B}]^1 = k[\text{B}]$$

To find the value of k, we just pick one of the 3 experiments and plug those values into the rate law and solve for k. I choose experiment 1:

$$0.001762\,\frac{\text{M}}{\text{s}} = k(0.200\text{ M})$$
$$k = \frac{0.001762\,\frac{\text{M}}{\text{s}}}{0.200\text{ M}}$$
$$k = 0.00881\text{ s}^{-1}\ \{3\text{ sig. figs}\}$$