UNIT 5 FREE-RESPONSE QUESTION
Kinetics

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Directions: This question is a long free-response question that requires about 23 minutes to answer and is worth 10 points. Show your work for each part in the space provided after that part. Examples and equations may be included in your responses where appropriate. For calculations, clearly show the method used and the steps involved in arriving at your answers. You must show your work to receive credit for your answer. Pay attention to significant figures.

In a chemistry class, students study the rates of three different chemical reactions. Answer questions about these three reactions, as shown below.

(a) A chemistry student studies the reaction of the peroxydisulfate ion with iodide ions, as shown in the balanced equation below. She carries out three different trials to measure the initial rate of formation of $I_3^-(aq)$, and the results are given in the table.

$$S_2O_8^{2-}(aq) + 3\ I^-(aq) \rightarrow 2\ SO_4^{2-}(aq) + I_3^-(aq)$$

Trial	$[S_2O_8^{2-}]$	$[I^-]$	Initial Rate of Formation of I_3^-
1	0.250 *M*	0.100 *M*	1.55×10^{-4} mol·L^{-1}·s^{-1}
2	0.500 *M*	0.100 *M*	3.10×10^{-4} mol·L^{-1}·s^{-1}
3	0.250 *M*	0.300 *M*	4.65×10^{-4} mol·L^{-1}·s^{-1}

(i) Write the rate law for the reaction.

(ii) Determine the rate constant of the reaction at this temperature, with appropriate units.

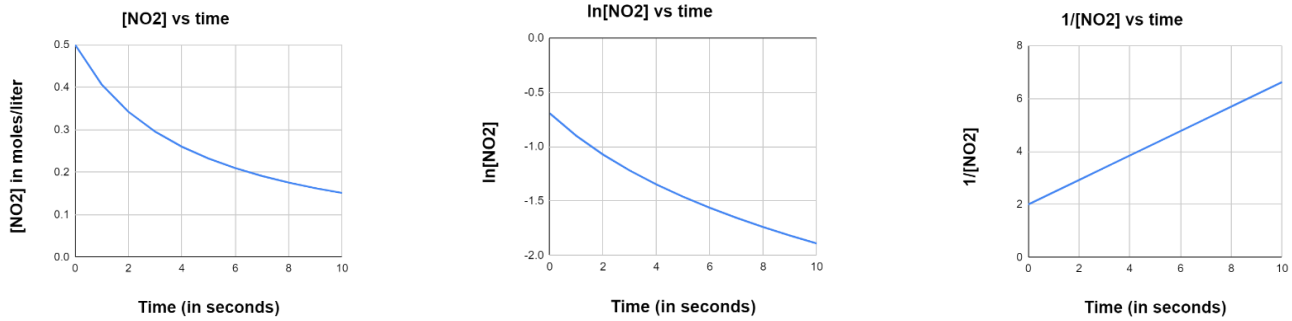
(iii) Use the data above the calculate the initial rate of appearance of SO_4^{2-} in Trial 3.

(iv) The student makes the claim that the reaction of peroxydisulfate with iodide ions take place in one step. Do you agree or disagree with the student's claim? Use information given in the balanced equation and/or the data table to defend your answer.

(b) Another student studies the rate of reaction for the decomposition of NO_2 gas, as represented by the following equation.

$$NO_2(g) \rightarrow NO(g) + O(g)$$

He makes three graphs, comparing the concentration of $[NO_2]$ versus time, the natural logarithm of $[NO_2]$ versus time, and $1/[NO_2]$ versus time, as shown below.



(i) Write the rate law for this reaction.

(ii) Without doing any calculations, state how the student could determine the rate constant for this reaction.

(c) A different student studies the two-step reaction mechanism shown below:

$$NO_2Cl \rightarrow NO_2 + Cl \quad \text{(slow)}$$

$$\underline{NO_2Cl + Cl \rightarrow NO_2 + Cl_2} \quad \text{(fast)}$$

$$2\ NO_2Cl \rightarrow 2\ NO_2 + Cl_2$$

(i) The student notes that Cl appears in the reaction mechanism, although it does not appear in the overall balanced equation. Explain the purpose of Cl in this mechanism.

(ii) Write the rate law for this reaction.

(iii) As the reaction proceeds, the concentration of NO_2Cl decreases. If the rate constant for this reaction at a certain temperature is equal to 3.6×10^{-2} min^{-1}, calculate the time required for the concentration of NO_2Cl to drop from 1.0×10^{-2} M to 9.4×10^{-4} M at this temperature.