Kinetics Practice Exam

Note: All problems included in this practice exam are drawn from problems used in previous semesters. Exams typically include 7 or 8 problems that are a mixture of qualitative problems calling for written explanations and quantitative problems that involve calculations and, in some cases, written explanations.

On the following pages are problems covering material in kinetics. Read each question carefully and consider how you will approach it before you put pen or pencil to paper. If you are unsure how to answer a question, then move on to another question; working on a new question may suggest an approach to a question that is more troublesome. If a question requires a written response, be sure that you answer in complete sentences and that you directly and clearly address the question. No brain dumps allowed! Generous partial credit is available, but only if you include sufficient work for evaluation and that work is relevant to the question.

Problem	Points	Maximum	Problem	Points	Maximum
1		12	5		16
2		12	6		16
3		12	7		16
4		16	Total		100

A few constants are given here; other information is included within individual problems.

- density (d) of water is 1.00 g/mL
- specific heat (S) of water is 4.184 J/g • °C
- the gas constant (R) is 8.314 $J/mol_{rxn} \bullet K$
- Faraday's constant (F) is 96,485 J/V • mol e^-
- water's dissociation constant (K_w) is 1.00×10^{-14}

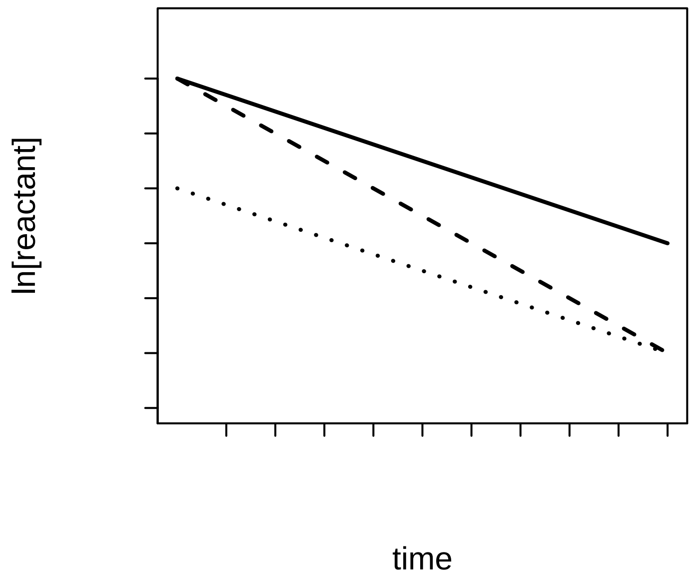

Figure 1: Experiment 1: solid line; Experiment 2: dashed line; Experiment 3: dotted line

Problem 1. Figure 1 shows results for three experiments run under conditions where the reaction's kinetics depend on a single reactant. Two experiments were run at the same temperature and a third experiment was run at a different temperature. Which experiment was run at a different temperature?

Problem 2. Consider the reaction $H_2(g) + I_2(g) \rightarrow 2HI(g)$, which is first order in H_2 and in I_2. For each of the following, predict whether the stated action will increase, decrease, or leave unchanged the reaction's rate and support each answer in a single sentence.

an increase in the reaction's temperature

an increase in the volume of the reaction vessel

the addition of a catalyst

the addition of an inert gas, such as Ar

Problem 3. The following information is known to you about a reaction in which A first reacts to form B, which, in turn, reacts to form C:

- the reaction A $\rightarrow$ C is exothermic
- the reaction's rate-determining step is B $\rightarrow$ C

Draw a reaction energy diagram that is consistent with this information.

Problem 4. Americium–241, ^{241}Am, is a radioactive isotope used in some smoke detectors. The first-order rate constant for its radioactive decay is 1.63×10^{-3} yr^{-1}. What percentage of the ^{241}Am originally present in a smoke detector remains after 34.0 months?

Problem 5. *Mycobacterium avium* is a human pathogen responsible for some respiratory infections. Although it is sometimes found in hot tubs and swimming pools, adding a disinfectant to the water destroys the pathogen. When using ClO_2 as a disinfectant, the rate constant for the pathogen's inactivation is 0.267 L/mg $\bullet$ min at a temperature of 5°C and 3.45 L/mg $\bullet$ min at a temperature of 30°C. What is the activation energy for the pathogen's destruction?

Problem 6. An important reaction in atmospheric chemistry is the oxidation of carbon monoxide to carbon dioxide using nitrogen dioxide

$$\mathrm{CO}(g) + \mathrm{NO_2}(g) \rightarrow \mathrm{CO_2}(g) + \mathrm{NO}(g)$$

The following data were gathered during a kinetic study of this reaction at 540 K.

$[\mathrm{CO}]_0$ (M)	$[\mathrm{NO_2}]_0$ (M)	Initial Rate (M/hr)
5.1×10^{-4}	3.5×10^{-5}	3.4×10^{-8}
5.1×10^{-4}	7.0×10^{-5}	6.8×10^{-8}
5.1×10^{-4}	1.8×10^{-5}	1.7×10^{-8}
1.0×10^{-3}	3.5×10^{-5}	6.8×10^{-8}
1.5×10^{-3}	8.5×10^{-5}	

Using this data, determine the rate law for the reaction and the value of the rate constant (with appropriate units). When you are done, fill in the missing rate in the data table.

Problem 7. The reaction $2\mathrm{NO}(g) + \mathrm{Cl_2}(g) \rightarrow 2\mathrm{NOCl}(g)$ is one of many reactions important in atmospheric chemistry. Under conditions where the partial pressure of $\mathrm{Cl_2}$ is significantly greater than the partial pressure of NO, a plot of $(P_{NO})^{-1}$ as a function of time is linear. The following mechanism is proposed for this reaction

$$\mathrm{NO}(g) + \mathrm{Cl_2}(g) \rightarrow \mathrm{NOCl_2}(g)$$

$$\mathrm{NOCl_2}(g) + \mathrm{NO}(g) \rightarrow 2\mathrm{NOCl}(g)$$

Is this a plausible mechanism for this reaction? In a paragraph of four to six sentences, provide a convincing explanation for your decision.