APChem - Unit 8 Kinetics Review Packet

Version A

Name: _____

Period: _____

AP* Chemistry: Kinetics Practice MC REDESIGN

NO CALCULATORS MAY BE USED

Note: For all questions, assume that the temperature is 298 K, the pressure is 1.00 atmosphere, and solutions are aqueous unless otherwise specified.

Directions: Each of the questions or incomplete statements below is followed by four suggested answers or completions. Select the one that is best in each case and then fill in the corresponding oval on the answer sheet.

1. Each of the following factors can affect the forward rate of a chemical reaction EXCEPT

   A) temperature
   B) concentration of reactants of the forward reaction
   C) removal of some of the products of the forward reaction
   D) physical state or state of subdivision of solid reactants

2. The half-life for radioactive element X is 10.0 min. What weight of X was originally present in a sample if 40. grams is left after 60. minutes?

   A) 320. grams
   B) 640. grams
   C) 1,280. grams
   D) 2,560 grams

3. Which of the following has the least effect on the rate of a reaction?

   A) adding a solid catalyst to a gas phase reaction
   B) adding a solid catalyst to a liquid phase reaction
   C) adding inert miscible liquid to a liquid phase reaction
   D) adding inert gas to a gas phase reaction at constant volume

Questions 4 and 5 refer to the steps of a mechanism proposed for the reaction of nitrogen(II) oxide with hydrogen.

$NO(g) + NO(g)$	$N_2O_2(g)$	fast equilibrium
$N_2O_2(g) + H_2(g)$	$N_2O(g) + H_2O(g)$	slow
$N_2O(g) + H_2(g)$	$N_2(g) + H_2O(g)$	fast

4. Which is the equation for the overall reaction?

   A) $NO(g) + NO(g) \rightarrow N_2(g) + H_2O(g)$
   B) $2\ NO(g) + 2\ H_2(g) \rightarrow N_2(g) + 2\ H_2O(g)$
   C) $NO(g) + N_2O(g) + H_2(g) \rightarrow N_2(g) + H_2O(g)$
   D) $2\ NO(g) + 2\ H_2(g) + N_2O_2(g) \rightarrow N_2O(g) + N_2(g) + 2\ H_2O(g)$

5. Which rate law is consistent with this mechanism?

   A) rate = $k\ [NO]^2$
   B) rate = $k\ [NO]^2\ [H_2]$
   C) rate = $k\ [N_2O]\ [H_2]$
   D) rate = $k\ [N_2O_2]\ [H_2]\ [NO]^2$

6. $$2\ A(g) + B(g) \rightarrow 2\ C(g)$$

   When the concentration of substance B in the reaction above is doubled, all other factors being held constant, it is found that the rate of the reaction remains unchanged. The most probable explanation for this observation is that

   A) the order of the reaction with respect to substance B is 1
   B) substance B is not involved in any of the steps in the mechanism of the reaction
   C) substance B is not involved in the rate-determining step of the mechanism, but is involved in subsequent steps
   D) substance B is probably a catalyst, and as such, its effect on the rate of the reaction does not depend on its concentration

7. The isomerization of cyclopropane to propylene is a first-order process with a half-life of 19 minutes at 500°C. The time it takes for the partial pressure of cyclopropane to decrease from 1.0 atmosphere to 0.125 atmosphere at 500°C is closest to

   A) 38 minutes
   B) 57 minutes
   C) 76 minutes
   D) 152 minutes

Questions 8 and 9 refer to the following reaction and its experimental data.

$$2\ A + B + C \rightarrow \text{products}$$

Four trials of the reaction above were carried out in order to determine its rate law. The following data were collected.

Trial	[A]	[B]	[C]	Initial rate $M\ sec^{-1}$
1	0.02	0.02	0.02	1.6×10^{-3}
2	0.01	0.02	0.02	8.0×10^{-4}
3	0.01	0.04	0.02	1.6×10^{-3}
4	0.01	0.04	0.03	1.6×10^{-3}

8. As any trial of this reaction proceeds at constant temperature, the rate of the reaction

A) remains the same because no catalyst is added
B) remains the same because the temperature is constant
C) decreases because the concentrations of the reactants decrease
D) decreases because the effectiveness of collisions between molecules decreases

9. Based on the data provided, what is the rate law?

A) Rate = k [A]^2
B) Rate = k [B][C]
C) Rate = k [A][B]
D) Rate = k [A][B][C]

10.

$Cl_2(g) \rightarrow 2\ Cl(g)$	fast equilibrium
$Cl(g) + CHCl_3(g) \rightarrow HCl(g) + CCl_3(g)$	slow
$CCl_3(g) + Cl(g) \rightarrow CCl_4(g)$	fast

The reaction between chlorine and chloroform in the gas phase which is known to proceed according to the mechanism above. According to this mechanism, what is the overall reaction?

A) $Cl_2(g) \rightarrow CCl_4(g)$
B) $CHCl_3(g) + Cl_2(g) \rightarrow HCl(g) + CCl_4(g)$
C) $Cl(g) + CHCl_3(g) \rightarrow H(g) + CCl_4(g)$
D) $2\ CHCl_3(g) + Cl_2(g) \rightarrow 2\ HCl(g) + CCl_4(g) + CCl_3(g)$

11. Which is a correct comparison of the characteristics of a catalyzed reaction to the corresponding characteristics of the same reaction without a catalyst present?

    A) Their energies of activation are the same.
    B) Their enthalpies of reaction are the same.
    C) Their free energies of reaction are the same.
    D) Both their enthalpies of reaction and their free energies are the same.

12. Which of the following is most closely associated with relatively slow rates of chemical reaction?

    A) high concentration of reactants
    B) low energy of activation
    C) the presence of a catalyst
    D) strong bonds in reaction molecules

13. In any first order reaction, as the reaction proceeds at constant temperature, which describes the corresponding effects on k (the rate constant) and *rate*?

	k	***rate***
A)	remains the same	decreases
B)	remains the same	remains the same
C)	remains the same	increases
D)	decreases	remains the same

14. The reaction between H_2 and NO occurs according to the equation

$$2\ H_2(g) + 2\ NO(g) \rightarrow 2\ H_2O(g) + N_2(g)$$

Six trials of the reaction were carried out. The initial rate of change of pressure for each trial was measured and recorded.

	Initial Pressure (atm)		**Initial Rate**
Trial	$\mathbf{P_{NO}}$	$\mathbf{P_{H_2}}$	**Δatm min^{-1}**
I	0.50	0.09	0.025
II	0.50	0.18	0.050
III	0.50	0.27	0.075
IV	0.09	0.80	0.0063
V	0.18	0.80	0.025
VI	0.27	0.80	0.056

Based on these results, what is the rate law for this reaction?

A) RATE = $k\,(P_{NO})^0\,(P_{H2})^2$
B) RATE = $k\,(P_{NO})^1\,(P_{H2})^1$
C) RATE = $k\,(P_{NO})^2\,(P_{H2})^0$
D) RATE = $k\,(P_{NO})^2\,(P_{H2})^1$

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YOU MAY USE YOUR CALCULATOR

Directions: Questions 1 and 2 are long constructed-response questions that should require about 15 minutes each to answer. Questions 3 and 4 are short constructed-response questions that should require about seven minutes each to answer. Read each question carefully and write your response in the space provided following each question. Your responses to these questions will be scored on the basis of the accuracy and relevance of the information cited. Explanations should be clear and well organized. Specific answers are preferable to broad, diffuse responses. For calculations, clearly show the method used and the steps involved in arriving at your answers. It is to your advantage to do this, since you may obtain partial credit if you do and you will receive little or no credit if you do not. Be sure to write all your answers to the questions on the lined pages following the question set.

$$H_2(g) + Cl_2(g) \rightarrow 2\,HCl(g)$$

1. The table below gives data for a reaction rate study of the reaction represented above.

Experiment	Initial $[H_2]$ (mol L^{-1})	Initial $[Cl_2]$ (mol L^{-1})	Initial Rate of Formation of HCl (mol L^{-1} s^{-1})
1	0.00100	0.000500	1.82×10^{-12}
2	0.00200	0.000500	3.64×10^{-12}
3	0.00200	0.000250	1.82×10^{-12}

(a) Determine the order of the reaction with respect to H_2 and justify your answer.

(b) Determine the order of the reaction with respect to Cl_2 and justify your answer.

(c) Write the overall rate law for the reaction.

(d) Write the units of the rate constant.

(e) Predict the initial rate of the reaction if the initial concentration of H_2 is 0.00300 mol L^{-1} and the initial concentration of Cl_2 is 0.000500 mol L^{-1}.

The gas-phase decomposition of nitrous oxide has the following two-step mechanism.

Step 1: $N_2O \rightarrow N_2 + O$

Step 2: $O + N_2O \rightarrow N_2 + O_2$

Write the balanced equation for the overall reaction.

(f) Is the oxygen atom, O, a catalyst for the reaction or is it an intermediate? Explain.

(g) Identify the slower step in the mechanism if the rate law for the reaction was determined to be $rate = k[N_2O]$. Justify your answer.

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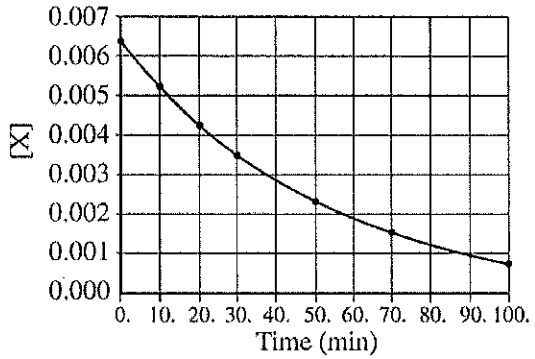
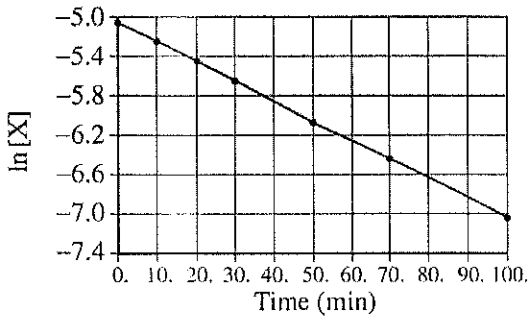
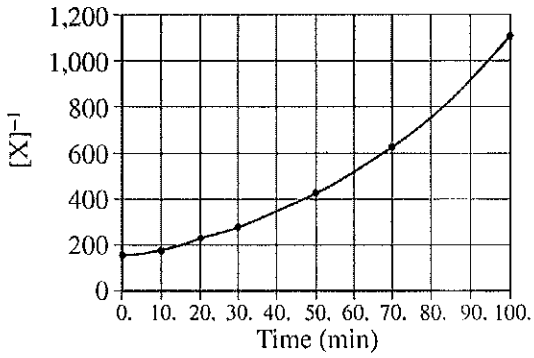
$$X \rightarrow 2Y + Z$$

2. The decomposition of gas X to produce gases Y and Z is represented by the equation above. In a certain experiment, the reaction took place in a 5.00 L flask at 428 K. Data from this experiment were used to produce the information in the table below, which is plotted in the graphs that follow.

Time (minutes)	[X] (mol L^{-1})	ln [X]	$[X]^{-1}$ ($L\ mol^{-1}$)
0	0.00633	−5.062	158
10.	0.00520	−5.259	192
20.	0.00427	−5.456	234
30.	0.00349	−5.658	287
50.	0.00236	−6.049	424
70.	0.00160	−6.438	625
100.	0.000900	−7.013	1,110







(a) How many moles of X were initially in the flask?

(b) How many molecules of Y were produced in the first 20. minutes of the reaction?

(c) What is the order of this reaction with respect to X? Justify your answer.

(d) Write the rate law for this reaction.

(e) Calculate the specific rate constant for this reaction. Specify units.

(f) Calculate the concentration of X in the flask after a total of 150. minutes of reaction.

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3. An environmental concern is the depletion of O_3 in Earth's upper atmosphere, where O_3 is normally in equilibrium with O_2 and O. A proposed mechanism for the depletion of O3 in the upper atmosphere is shown below.

Step I $O_3 + Cl \rightarrow O_2 + ClO$

Step II $ClO + O \rightarrow Cl + O_2$

(a) Clearly identify the intermediate in the mechanism above. Justify your answer.

(b) If the rate law for the overall reaction is found to be $rate = k[O_3][Cl]$, determine the following.

(i) The overall order of the reaction

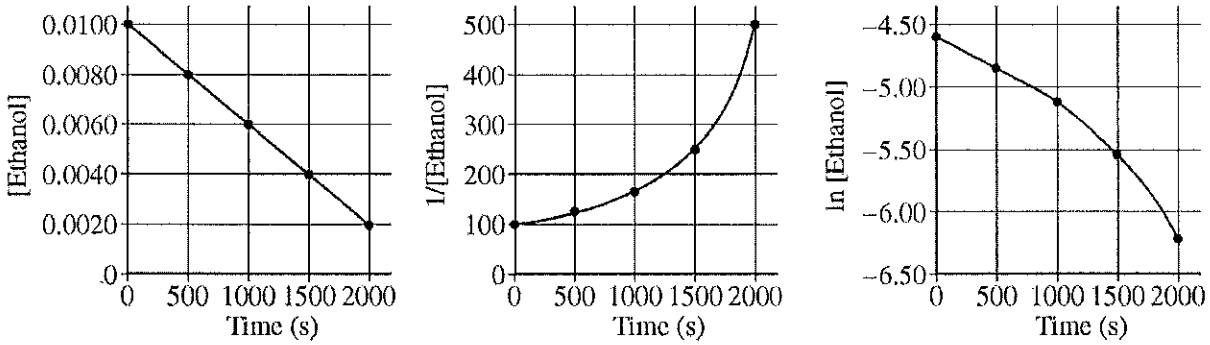
(ii) Appropriate units for the rate constant, k

(iii) The rate-determining step of the reaction, along with justification for your answer

4. An experiment is performed at a very high temperature where a sample of ethanol gas and a copper catalyst are placed in a rigid, empty 1.0 L flask. The temperature of the flask is held constant, and the initial concentration of the ethanol gas is 0.0100 *M*. The ethanol begins to decompose according to the chemical reaction represented below.

$$CH_3CH_2OH(g) \xrightarrow{Cu} CH_3CHO(g) + H_2(g)$$

The concentration of ethanol gas over time is used to create the three graphs below.



Given that the reaction order is zero, one, or two, use the information in the graphs to respond to the following.

(a) Determine the order of the reaction with respect to ethanol. Justify your answer.

(b) Write the rate law for the reaction.

(c) Determine the rate constant for the reaction, including units.

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