

AP Chemistry
Quiz : Chapter 14
Topic: Kinetics

Name(s) _____

Date _____ Period _____

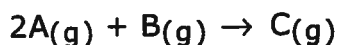
I. In the spaces provided to the left, write in the answer that best completes each statement below. **No calculators, please.** (2 pts. each)

- I. For a first order reaction a plot of $\ln [A]_t$ versus time is linear. **T**
- II. The half-life of a particular first-order reaction is constant. **T**
- III. The energy of activation decreases as the rate constant becomes smaller and the reaction rate increases. **F**
- IV. In the Arrhenius equation, the frequency factor, A, is related to the frequency of collisions and the probability that those collisions are favorably oriented for the reaction. **T**
- V. Remember to work at a steady rate for this quiz and notes help to catalyze your results. **T**

B 1. Which of the above statements are **incorrect**? Only...

- a) I **b) III** c) II and IV d) I, II and IV e) I, III, and V

II. Questions 2 and 3: Consider the reaction and its rate law given below:



$$\text{Rate} = k[A]^2[B]$$

At the beginning of one trial of this reaction, $[A] = 4.0$ and $[B] = 1.0$. The observed rate was $0.048 \text{ mol C} \cdot \text{L}^{-1} \cdot \text{sec}^{-1}$.

A 2. Which is the label for the rate constant?

- a. $\text{L}^2 \cdot \text{mol}^{-2} \cdot \text{sec}^{-1}$
b. $\text{mol}^2 \cdot \text{L}^{-2} \cdot \text{sec}^{-1}$
c. $\text{L} \cdot \text{mol}^{-2} \cdot \text{sec}^{-1}$
d. $\text{L}^2 \cdot \text{sec} \cdot \text{mol}^{-1}$
e. $\text{L}^2 \cdot \text{sec} \cdot \text{mol}^{-2}$

Overall order $2+1=3$

$$\frac{1}{\text{M}^2 \text{sec}}$$

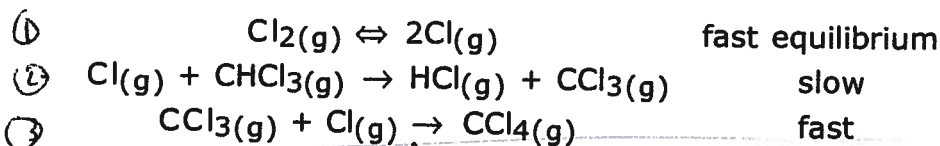
C 3. Which applies to this system when its temperature is increased at constant volume?

- I. $[A]$ decreases at a greater rate. ✓
II. The value for k, the rate constant, remains the same.
III. The rate of the reaction increases. ✓

- a. I only
b. II only
c. I and III only
d. II and III only
e. I, II, and III

If \nearrow Temp stays the same

III. Question #4: The reaction between chlorine and chloroform in the gas phase is known to proceed according to the mechanism below.



C 4. According to this mechanism, what is the rate law?

a. $\text{RATE} = k[\text{Cl}_2]^2$

b. $\text{RATE} = k[\text{Cl}_2]^2[\text{CHCl}_3]$

c. $\text{RATE} = k[\text{Cl}_2]^{\frac{1}{2}}[\text{CHCl}_3]$

d. $\text{RATE} = k \frac{[\text{CHCl}_3]}{[\text{Cl}_2]^{\frac{1}{2}}}$

e. $\text{RATE} = k \frac{[\text{CHCl}_3]}{[\text{Cl}]^2}$

$\text{Rate}_f = \text{Rate}_r$

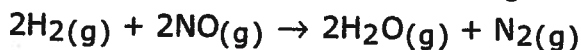
$k_f [\text{Cl}_2] = k_r [\text{Cl}]^2$

Substitution $\rightarrow [\text{Cl}] = \frac{k_f}{k_r} \sqrt{[\text{Cl}_2]}$

$\text{Rate}_r = k_2 [\text{Cl}] [\text{CHCl}_3]$

$\text{Rate} = k [\text{Cl}_2]^{\frac{1}{2}} [\text{CHCl}_3]$

D 5. The reaction between H_2 and NO occurs according to the equation



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

Trial	Initial Pressure (atm)		Initial Rate
	P_{NO}	P_{H_2}	$\Delta \text{atm}/\text{min}$
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

1st and w/ respect to H_2

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

a. $\text{RATE} = k(P_{\text{NO}})^0(P_{\text{H}_2})^2$

b. $\text{RATE} = k(P_{\text{NO}})^1(P_{\text{H}_2})^2$

c. $\text{RATE} = k(P_{\text{NO}})^2(P_{\text{H}_2})^0$

d. $\text{RATE} = k(P_{\text{NO}})^2(P_{\text{H}_2})^1$

e. $\text{RATE} = k(P_{\text{NO}})^2(P_{\text{H}_2})^2$

$\left(\frac{.18}{.09}\right)^x = \frac{.025}{.0063}$

$2^x = 4$

$x = 2$

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Question 3

The first-order decomposition of a colored chemical species, X, into colorless products is monitored with a spectrophotometer by measuring changes in absorbance over time. Species X has a molar absorptivity constant of $5.00 \times 10^3 \text{ cm}^{-1} \text{ M}^{-1}$ and the path length of the cuvette containing the reaction mixture is 1.00 cm. The data from the experiment are given in the table below.

[X] (M)	Absorbance	Time (min)
?	0.600	0.0
4.00×10^{-5}	0.200	35.0
3.00×10^{-5}	0.150	44.2
1.50×10^{-5}	0.075	?

(a) Calculate the initial concentration of the colored species.

$$c = \frac{A}{\epsilon b} = \frac{0.600}{(5.00 \times 10^3 \text{ cm}^{-1} \text{ M}^{-1})(1.00 \text{ cm})} = 1.20 \times 10^{-4} \text{ M}$$

OR

$$A_0 = abc_0 \quad A_1 = abc_1$$

$$\frac{A_0}{c_0} = \frac{A_1}{c_1} \quad \frac{0.600}{1.20 \times 10^{-4}} = \frac{0.200}{4.00 \times 10^{-5}}$$

$$c_0 = 1.20 \times 10^{-4} \text{ M}$$

1 point for concentration of X

(b) Calculate the rate constant for the first-order reaction using the values given for concentration and time. Include units with your answer.

Using the first two readings,

$$\ln[X]_1 - \ln[X]_0 = -kt \quad \text{OR} \quad \ln \frac{[X]_1}{[X]_0} = -kt$$

$$\ln \frac{4.00 \times 10^{-5}}{1.20 \times 10^{-4}} = -t(35.0 \text{ min})$$

$$\ln(0.333) = -k(35.0 \text{ min})$$

$$-1.10 = -k(35.0 \text{ min})$$

$$k = 3.14 \times 10^{-2} \text{ min}^{-1}$$

1 point for correct units

(c) Calculate the number of minutes it takes for the absorbance to drop from 0.600 to 0.075.

$$\ln \frac{[X]_t}{[X]_0} = -kt$$

$$\ln \frac{1.50 \times 10^{-5}}{1.20 \times 10^{-4}} = (-3.14 \times 10^{-2} \text{ min}^{-1})t$$

$$\ln(0.125) = (-3.14 \times 10^{-2} \text{ min}^{-1})t$$

$$-2.08 = (-3.14 \times 10^{-2} \text{ min}^{-1})t$$

$$t = 66.2 \text{ min}$$

1 point for correct substitution

1 point for correct answer

Note: students may use half-lives to answer this question.

(d) Calculate the half-life of the reaction. Include units with your answer.

$$\ln \frac{[X]_t}{[X]_0} = -kt$$

$$\ln \frac{0.5[X]_0}{[X]_0} = (-3.14 \times 10^{-2} \text{ min}^{-1})t_{1/2}$$

$$\ln(0.5) = (-3.14 \times 10^{-2} \text{ min}^{-1})t_{1/2}$$

$$-0.693 = (-3.14 \times 10^{-2} \text{ min}^{-1})t_{1/2}$$

$$22.1 \text{ min} = t_{1/2}$$

OR

$$t_{1/2} = \frac{0.693}{k} = \frac{0.693}{3.14 \times 10^{-2} \text{ min}^{-1}} = 22.1 \text{ min}$$

1 point for correct magnitude

1 point for the correct units

(1 point for the half-life equation if no k is given)

(e) Experiments were performed to determine the value of the rate constant for this reaction at various temperatures. Data from these experiments were used to produce the graph below, where T is temperature. This graph can be used to determine the activation energy, E_a , of the reaction.

(i) Label the vertical axis of the graph.

The vertical axis should be labeled $\ln k$.

1 point

(ii) Explain how to calculate the activation energy from this graph.

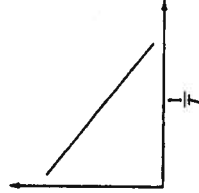
The slope of the line is related to the activation energy:

$$\text{slope} = -\frac{E_a}{R}$$

To determine the activation energy for the reaction, multiply the slope by $-8.314 \text{ J mol}^{-1} \text{ K}^{-1}$.

1 point for recognizing that the slope must be measured

1 point for the correct explanation of how to obtain the activation energy



ln k

1/T