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:

$2A(g) + B(g) \rightarrow C(g)$ 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 mol C • L^{-1} • sec^{-1}.

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

Overall order 2+1 = 3

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

a. L^2 • mol^{-2} • sec^{-1}
b. mol^2 • L^{-2} • sec^{-1}
c. L • mol^{-2} • sec^{-1}
d. L^2 • sec • mol^{-1}
e. L^2 • sec • mol^{-2}

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. ✓

If Temp stays the same

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

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

①	$Cl_{2(g)} \Leftrightarrow 2Cl_{(g)}$	fast equilibrium
②	$Cl_{(g)} + CHCl_{3(g)} \rightarrow HCl_{(g)} + CCl_{3(g)}$	slow
③	$CCl_{3(g)} + Cl_{(g)} \rightarrow CCl_{4(g)}$	fast

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

a. RATE = $k[Cl_2]^2$

b. RATE = $k[Cl_2]^2[CHCl_3]$

(c.) RATE = $k[Cl_2]^{\frac{1}{2}}[CHCl_3]$

d. RATE = $k\frac{[CHCl_3]}{[Cl_2]^{\frac{1}{2}}}$

e. RATE = $k\frac{[CHCl_3]}{[Cl]^2}$

Rate$_f$ = Rate$_R$

$k_f[Cl_2] = k_R[Cl]^2$

$[Cl] = \frac{k_f}{k_R}\sqrt{Cl_2}$

Substitute →

Rate $= k_2[Cl][CHCl_3]$

Rate $= k[Cl_2]^{1/2}[CHCl_3]$

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

$$2H_{2(g)} + 2NO_{(g)} \rightarrow 2H_2O_{(g)} + N_{2(g)}$$

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

Trial	Initial Pressure (atm) P_{NO}	P_{H_2}	Initial Rate Δatm/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. RATE = $k(P_{NO})^0(P_{H_2})^2$

b. RATE = $k(P_{NO})^1(P_{H_2})^2$

c. RATE = $k(P_{NO})^2(P_{H_2})^0$

(d) RATE = $k(P_{NO})^2(P_{H_2})^1$

e. RATE = $k(P_{NO})^2(P_{H_2})^2$

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

$2^x = 4$

$x = 2$

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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 5.00×10^3 cm^{-1} 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.

$A = abc$ $c = \frac{A}{ab} = \frac{0.600}{(5.00\times10^3\ \text{cm}^{-1} M^{-1})(1.00\ \text{cm})}$ $= 1.20 \times 10^{-4}\ M$ *OR* $A_0 = abc_0 \quad A_1 = abc_1$ $\frac{A_0}{c_0} = \frac{A_1}{c_1} \quad \frac{0.600}{c_0} = \frac{0.200}{4.00\times10^{-5}}$ $c_0 = 1.20 \times 10^{-4}\ M$	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, $\ln[X]_t - \ln[X]_0 = -kt$ *OR* $\ln\frac{[X]_t}{[X]_0} = -kt$ $\ln\frac{4.00\times10^{-5}}{1.20\times10^{-4}} = -k(35.0\ \text{min})$ $\ln(0.333) = -k(35.0\ \text{min})$ $-1.10 = -k(35.0\ \text{min})$ $k = 3.14 \times 10^{-2}\ \text{min}^{-1}$	1 point for magnitude and correct sign of rate constant 1 point for correct units

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

$\ln\frac{[X]_t}{[X]_0} = -kt$ $\ln\frac{1.50\times10^{-5}}{1.20\times10^{-4}} = (-3.14 \times 10^{-2}\ \text{min}^{-1})\,t$ $\ln(0.125) = (-3.14 \times 10^{-2}\ \text{min}^{-1})\,t$ $-2.08 = (-3.14 \times 10^{-2}\ \text{min}^{-1})\,t$ $t = 66.2$ 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* $t_{1/2} = \frac{0.693}{k}$ $t_{1/2} = \frac{0.693}{3.14\times10^{-2}\ \text{min}^{-1}} = 22.1$ 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 J mol^{-1} 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