Mr. Bracken
AP Chemistry

Name _____
Period _____

Kinetics Worksheet #4

1972 **$2\,A + 2\,B \rightarrow C + D$**

The following data about the reaction shown above were obtained from three experiments:

Trial	[A]	[B]	Rate of Formation of C ($M\ min^{-1}$)
1	0.60	0.15	6.3×10^{-3}
2	0.20	0.60	2.8×10^{-3}
3	0.20	0.15	7.0×10^{-4}

(a) What is the rate law for this reaction?

(b) What is the numerical value of the rate constant *k* ? What are the units for *k* ?

1981 B **$A + 2\,B \rightarrow 3\,C + D$**

For the reaction above, carried out in a solution at $30^{o}C$, the following kinetic data were obtained:

Trial	[A]	[B]	Rate of Reaction (M/hr)
1	0.240	0.480	8.00
2	0.240	0.120	2.00
3	0.360	0.240	9.00
4	0.120	0.120	0.500
5	0.240	0.0600	1.00
6	0.0140	1.35	?

(a) Write the rate law expression for this reaction.

(b) Calculate the value of the specific rate constant *k* at $30^{o}C$ and specify its units.

(c) Calculate the initial rate of this reaction at $30^{o}C$ for Trial #6.

1987 B $\mathbf{2\,A + B \rightarrow 2\,C + 2\,D + E}$

Trial	Initial [A]	Initial [B]	Initial Rate of Formation of C ($M\ min^{-1}$)
1	0.0836	0.202	5.2×10^{-5}
2	0.0836	0.404	2.08×10^{-4}
3	0.0418	0.404	1.04×10^{-4}
4	0.0316	?	1.27×10^{-4}

(a) According to the data shown, what is the rate law for the reaction above?

(b) On the basis of the rate law from part (a), calculate the specific rate constant. Specify the units.

(c) What is the numerical value for the initial rate of disappearance of B for Trial #1 ?

(d) Calculate the initial concentration of **B** for Trial #4.

1991 B $\mathbf{2\ ClO_2 + F_2 \rightarrow 2\ ClO_2F}$

The following results were obtained when the reaction represented above was studied at 25°C.

Trial	Initial $[ClO_2]$	Initial $[F_2]$	Initial Rate of Increase of ClO_2F ($M\ min^{-1}$)
1	0.010	0.10	2.4×10^{-3}
2	0.010	0.40	9.6×10^{-3}
3	0.020	0.20	9.6×10^{-3}

(a) Write the rate law expression for the reaction above.

(b) Calculate the numerical value for the rate constant and specify the units.

(c) In trial #2, what is the initial rate of decrease of $[F_2]$?

(d) Which of the two proposed reaction mechanisms shown below is consistent with the rate law developed in part (a) ? Justify your choice.

Mech #1:

$ClO_2 + F_2 \leftrightarrows ClO_2F_2$ *fast*

$ClO_2F_2 \rightarrow ClO_2F + F$ *slow*

$ClO_2 + F \rightarrow ClO_2F$ *fast*

Mech #2:

$F_2 \rightarrow 2\ F$ *slow*

$2\ ClO_2 + 2\ F \rightarrow 2\ ClO_2F$ *fast*

1997 B **$2\,A + B \rightarrow C + D$**

The following results were obtained when the reaction represented above was studied at 25°C.

Experiment	Initial [A]	Initial [B]	Initial Rate of Formation of C ($M\ min^{-1}$)
1	0.25	0.75	4.3×10^{-4}
2	0.75	0.75	1.3×10^{-3}
3	1.50	1.50	5.3×10^{-3}
4	1.75	?	8.0×10^{-3}

(a) Determine the order of the reaction with respect to A and to B.

(b) Write the rate law for the reaction. Calculate the value of the rate constant, specifying units.

(c) Determine the initial rate of change of [A] in Experiment #3.

(d) Determine the initial concentration of **B** in Experiment #4.

(e) Identify which of the reaction mechanisms represented below is consistent with the rate law developed in part (b). Justify your choice.

Mech #1: $A + B \leftrightarrows C + M$ *Fast equilibrium*
$M + A \rightarrow D$ *Slow*

Mech #2: $B \leftrightarrows M$ *Fast equilibrium*
$M + A \rightarrow C + X$ *Slow*
$A + X \rightarrow D$ *Fast*

Mech #3: $A + B \leftrightarrows M$ *Fast equilibrium*
$M + A \rightarrow C + X$ *Slow*
$X \rightarrow D$ *Fast*

Kinetics Worksheet #4
Bracken Answers

1972

(a) Rate = $k[A]^2[B]$
(b) $k = 0.12\ M^{-2}min^{-1}$

1981 B

(a) Rate = $k[A]^2[B]$
(b) $k = 289\ M^{-2}hr^{-1}$
(c) Rate = $0.0765\ M\ hr^{-1}$

1987 B

(a) Rate = $k[A][B]^2$
(b) $k = 0.0152\ M^{-2}min^{-1}$
(c) $2.6 \times 10^{-5}\ M\ min^{-1}$ (from balanced equation, C forms twice as fast as B disappears)
(d) [B] = 0.514 M

1991 B

(a) Rate = $k[ClO_2][F_2]$
(b) $k = 2.4\ M^{-1}min^{-1}$
(c) $4.8 \times 10^{-3}\ M\ min^{-1}$ (from balanced equation, $[F_2]$ decreases at half the rate ClO_2F appears)

(d) Mech #1: Rate = $k[ClO_2][F_2]$
Mech #2: Rate = $k[F_2]$

Mechanism #1, when all intermediates are removed, matches the rate law observed in the experimental data. Therefore, mechanism #1 is consistent.

1997 B

(a) Rate is first order with respect to A (compare trials 1 & 2)
Rate is first order with respect to B (compare trials 2 & 3)

(b) $k = 0.0023\ M^{-1}min^{-1}$
(c) $1.06 \times 10^{-2}\ M\ min^{-1}$
(d) [B] = 1.99 M

(e) Mech #1 Rate = $k[A]^2[B]\ [C]^{-1}$

Mech #2 Rate = $k[A][B]$

Mech #3 Rate = $k[A]^2[B]$

Mechanism #2 is consistent with the experimental data because it matches the observation that the rate is first order with respect to A and first order with respect to B.