Exercise 12.3
Initial Rates Method

Name: ________________________

Date:_________________ Per:_________

The rate law of a chemical reaction is a mathematical equation that describes how the reaction rate depends upon the concentration of each reactant.

The method of initial rates allows the values of these orders to be found by running the reaction multiple times under controlled conditions and measuring the rate of the reaction in each case. All variables are held constant from one run to the next, except for the concentration of one reactant. The order of that reactant concentration in the rate law can be determined by observing how the reaction rate varies as the concentration of that one reactant is varied.

Order of Reactant	**Change in Initial Rate when Conc. is Doubled**
First Order	Rate doubles
Second Order	Rate quadruples
Zero Order	Rate remains unchanged

The precise order of a reactant in a rate law may be calculated using the following formula:

$$\text{reactant order} = \frac{\log\left(\frac{\text{initial rate}_1}{\text{initial rate}_2}\right)}{\log\left(\frac{[x]_1}{[x]_2}\right)}$$

DIRECTIONS: Answer the following in the space provided.

1. Given the following equations and experimental data, write the correct
   a. Rate Law Expression
   b. Reaction Order
   c. Determine k, the Specific Rate Constant (including units)

A_2 + B_2 → 2 AB

Exp #	**[A_2]**	**[B_2]**	**Rate** (mole L^{-1} s^{-1})
1	0.001	0.001	0.01
2	0.001	0.002	0.02
3	0.001	0.003	0.03
4	0.001	0.004	0.04
5	0.002	0.004	0.16
6	0.003	0.004	0.36

Rate = ________________________

Reaction Order = _______________

k =

2. Given the following equations and experimental data, write the correct
   a. Rate Law Expression
   b. Reaction Order
   c. Determine k, the Specific Rate Constant (including units)

F + G → H

Exp #	**[F]**	**[G]**	**Rate** (mole L^{-1} s^{-1})
1	0.01	0.4	0.02
2	0.02	0.4	0.04
3	0.03	0.4	0.06
4	0.1	0.2	0.10
5	0.1	0.4	0.20
6	0.1	0.6	0.30

Rate = ________________________

Reaction Order = _______________

k =

3. Using the experimental data provided, determine the order of reaction with respect to each reactant, the rate law equation, the overall order of reaction, and calculate the rate law constant, k.

CO (g) + Cl_2 (g) → $COCl_2$ (g)

Experiment	**Initial Concentration (mol/L)**		**Initial Rate (mol/L•s)**
	CO	**Cl_2**	
1	0.12	0.20	0.121
2	0.24	0.20	0.241
3	0.12	0.40	0.483

Rate = ________________________

Reaction Order = _______________

k =

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4. Using the experimental data provided, determine the order of reaction with respect to each reactant, the rate law equation, the overall order of reaction, and calculate the rate law constant, k. Use the data to predict the reaction rate for Experiment 4.

$$2\ ICl\ (g) + H_2\ (g) \rightarrow I_2\ (aq) + 2\ HCl\ (g)$$

Experiment	Initial Concentration (mol/L)		Initial Rate (mol/L•s)
	ICl	**H_2**	
1	1.5	1.5	3.7×10^{-7}
2	3.0	1.5	7.4×10^{-7}
3	3.0	4.5	2.2×10^{-6}
4	4.7	2.7	?

5. Using the experimental data provided, determine the order of reaction with respect to each reactant, the rate law equation, the overall order of reaction, and calculate the rate law constant, k. Use the data to predict the reaction rate for Experiment 4.

$$NO_2\ (g) + O_3\ (g) \rightarrow NO_3\ (g) + O_2\ (g)$$

Experiment	Initial Concentration (mol/L)		Initial Rate (mol/L•s)
	NO_2	**O_3**	
1	0.21	0.70	6.3
2	0.21	1.39	12.5
3	0.38	0.70	11.4
4	0.66	0.18	?

6. Using the experimental data provided, determine the order of reaction with respect to each reactant, write the rate law, determine the overall order of the reaction, and calculate the rate law constant, k.

$$S_2O_8^{2-}\ (aq) + 3\ I^-\ (aq) \rightarrow 2\ SO_4^{2-}\ (aq) + I_3^-\ (aq)$$

Experiment	Initial Concentration (mol/L)		Initial Rate (mol/L•s)
	$S_2O_8^{2-}$	**I^-**	
1	0.15	0.21	1.14
2	0.22	0.21	1.70
3	0.22	0.12	0.98

7. The reduction of bromate ions, BrO_3^-, by bromide ions in acidic solution has a rate law:

$$\text{Rate} = k\ [BrO_3^-][Br^-][H^+]^2.$$

   a. What are the orders with respect to the reactants?

   b. What is the overall order?

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8. What are the units for each of the following if the concentrations are expressed in moles per liter and the time in seconds?
   a. rate of a chemical reaction: _________
   b. rate constant for a zero-order rate law: _________
   c. rate constant for a first-order rate law: _________
   d. rate constant for a second-order rate law: _________
   e. rate constant for a third-order rate law: _________

9. The reaction $2NO(g) + Cl_2(g) \rightarrow 2NOCl(g)$ was studied at -10°C. The following results were obtained where

$[NO]_0$ (mol/L)	$[Cl_2]_0$ (mol/L)	Initial Rate (mol/L·min)
0.10	0.10	0.18
0.10	0.20	0.36
0.20	0.20	1.45

   a. What is the rate law?

   b. What is the value of the rate constant?

10. The decomposition of nitrosyl chloride was studied: $2NOCl(g) \rightarrow 2NO(g) + Cl_2(g)$. The following results were obtained where

$[NOCl]_0$ (molecules/cm^3)	Initial Rate (molecules/cm^3·s)
3.0×10^{16}	5.98×10^{4}
2.0×10^{16}	2.66×10^{4}
1.0×10^{16}	6.64×10^{3}
4.0×10^{16}	1.06×10^{5}

   a. What is the rate law?

   c. Calculate the value of the rate constant?

   d. Calculate the value of the rate constant when concentrations are given in moles per liter.

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11. The reaction $I^-(aq) + OCl^-(aq) \rightarrow IO^-(aq) + Cl^-(aq)$ was studied and the following data were obtained:

$[I^-]_0$ (mol/L)	$[OCl^-]_0$ (mol/L)	Initial Rate (mol/L·min)
0.12	0.18	7.91×10^{-2}
0.060	0.18	3.95×10^{-2}
0.030	0.090	9.88×10^{-3}
0.24	0.090	7.91×10^{-2}

a. What is the rate law?

b. Calculate the value of the rate constant?

c. Calculate the initial rate for an experiment where both I^- and OCl^- are initially present at 0.15 mol/L.