Dougherty Valley HS Chemistry
Kinetics – Rate Laws

Worksheet #4

Name: **Period:** **Seat#:**

Mathematical Questions

- Show your work when applicable! Show units!
- Get an actual answer, including units! Box your answer!
- Some answers are provided. They are underlined at the end.
- For rate order type problems – be sure to include the following information. Your work does not need to be in chart format like this, but it does need to have all the information clearly identified if not using the chart format. Here is an example of what needs to be shown.

Trials being used	Which [ ] is held constant	Which [ ] is being changed and by what factor is it changed by	What factor is the rate changed by	Order based on rate data
1 & 3	$[H_2]$	$[O_2]$ x 2	x 2	1

1) Write the following for the single step reaction
$N_2 + 3\ H_2 \rightarrow 2\ NH_3$

a) The rate expression for the reaction

b) The order of the reaction for each of the reagents

c) The overall order of the reaction

2) The rate constant for the single step reaction $HNO_3 + NH_3 \rightarrow NH_4NO_3$ is 14.5 L /mol.sec. If the concentration of nitric acid is 0.050 M and the concentration of ammonia is 0.10 M, what will the rate of this reaction be?
Rate = 0.073 mol / L. sec

3) One step rxn of nitric oxide, NO, with chlorine, Cl_2,
$2NO(g) + Cl_2(g) \rightarrow 2NOCl(g)$.

a) Write the rate law.

b) What is the reaction order with respect to nitric oxide?

c) With respect to Cl_2?

d) What is the overall order?

4) $H_2S(aq) + Cl_2(aq) \rightarrow S(s) + 2HCl(aq)$ (assume single step)

a) Write the rate law

b) What is the reaction order with respect to H_2S

c) With respect to Cl_2?

d) What is the overall order?

5) For the reaction of hydrogen with iodine $H_2(g) + I_2(g) \rightarrow 2HI(g)$ relate the rate of disappearance of iodine vapor to the rate of formation of hydrogen iodide. *(Hint: this is NOT a rate law)*

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6) When two compounds, A and B, are mixed together, they form compound C, by a reaction that is not well understood. Fortunately, the following rate information was experimentally determined as shown

[A] (mol/L)	[B] (mol/L)	Rate (mol/L.sec)
0.050	0.050	4.0×10^{-3}
0.10	0.050	8.0×10^{-3}
0.050	0.10	1.6×10^{-2}

a) Determine the rate expression for this reaction

b) Determine the rate law for this reaction

c) Determine the rate constant for this reaction
k = 32L²/mol²sec

7) In experiments on the decomposition of azomethane, $CH_3NNCH_3(g) \rightarrow C_2H_6(g) + N_2(g)$ the following data were obtained:

Experiment	Initial [azomethane]	Rate
1	1.13E-2 M	2.8E-6 M/s
2	2.26E-2 M	5.6E-6 M/s

a) What is the rate expression for this reaction?

b) What is the rate law?

c) What is the value of the rate constant? *k=2.5E-4 s⁻¹*

8) Nitric acid, NO, reacts with hydrogen to give nitrous oxide, N_2O, and water.
$2NO(g) + H_2(g) \rightarrow N_2O(g) + H_2O(g)$
In a series of experiments, the following initial rates of disappearance of NO were obtained:

Experiment	Initial [NO]	Initial [H2]	Rate
1	6.4E-3 M	2.2E-3 M	2.6E-5 M/s
2	12.8E-3 M	2.2E-3 M	1.0E-4 M/s
3	6.4E-3 M	4.5E-3 M	5.1E-5 M/s

a) Find the rate law

b) Find the value of the rate constant for the reaction of NO *k = 2.9 x 10²/(M²s)*

9) Chlorine dioxide, ClO_2, is a reddish-yellow gas that is soluble in water. In basic solution it gives ClO_3^- and ClO_2^- ions. $2ClO_2 + 2OH^- \rightarrow ClO_3^- + ClO_2^- + H_2O$. To obtain the rate law, the following experiments were run and initial rate of the rxn of ClO_2 was determined.

Trial	Initial [ClO2]	Initial [OH-]	Rate
1	0.060 M	0.030 M	0.0248 *M/s*
2	0.020 M	0.030 M	0.00276 *M/s*
3	0.020 M	0.090 M	0.00828 *M/s*

a) Obtain the rate law

b) Obtain the value of the rate constant
k = 2.3 x 10²/(M²s)

10) Iodine ion is oxidized to hypoiodite ion, IO-, by hypochlorite ion ClO-, in basic solution.

The equation is: $I^- + ClO^- \xrightarrow{OH^-} IO^- + Cl^-$

The following initial-rate experiments were run and, for each, the initial rate of formation of IO- was determined.

Experiment	Initial [I-]	Initial [ClO-]	Initial [OH-]	Rate
1	0.010 M	0.020 M	0.010 M	12.2E-2 *M/s*
2	0.020 M	0.010 M	0.010 M	12.2E-2 *M/s*
3	0.010 M	0.010 M	0.010 M	6.1E-2 M/s
4	0.010 M	0.010 M	0.020 M	3.0E-2 M/s

a) Find the rate law

b) Find the value of the rate constant.

11) Look up the term "10 degree Celsius rule kinetics." What does this "10 degree rule" state? Is it always true?

12) Which of the following factors will change the ***rate*** of reaction, which factors will change the ***rate constant*** and which factors will change ***both***? Hint – look at the exponent in the Arrhenius equation and think about the factors that go into calculating the rate constant. $k = A\, e^{\frac{-Ea}{RT}}$

- Temperature
- Concentration
- Catalyst

13) Use the graphs to answer the following questions:

a) Label which graph is representing the effect temperature has on a reaction

b) Label which graph is representing the effect a catalyst has on a reaction

c) For the graph that represents the effect temperature has on a reaction – label which line is the colder temperature and which is the hotter temperature.

d) For the graph that represents the effect adding a catalyst has on a reaction – label which line is the reaction without a catalyst and which is with a catalyst.