NAME_____

Chapter 14 Kinetics

Worksheet 1: Show all work, including units in the problem and in the final answer.

Objective 1: Reaction Rates: General Considerations

1. In the Haber process for the production of ammonia,

$$N_2 + 3H_2 \rightarrow 2NH_3$$

What is the relationship between the rate of production of ammonia and the rate of consumption of hydrogen? (Rate expression)

2. Calculate the average rate over an interval of time, given the concentrations of a reactant or product at the beginning and end of that interval.

The decomposition of hydrogen peroxide was studied, and the following data were obtained at a particular temperature: $2H_2O_2 \rightarrow 2H_2O + O_2$

Time (s)	0	120	300	600	1200	1800	2400	3000	3600
$[H_2O_2]$ (M)	1.0	0.91	0.78	0.59	0.37	0.22	0.13	0.082	0.05
$[H_2O]$ (M)									
$[O_2]$ (M)									

Calculate the average rate of disappearance of hydrogen peroxide between 120 s and 1800 s.

Calculate the average rate of appearance of water between 600 s and 2400 s. _____

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Calculate the average rate of appearance of oxygen between 2400 s and 3600 s.

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3. Calculate instantaneous rates from a graph of reactant or product concentrations as a function of time.

The decomposition of dinitrogen pentoxide in the gas phase was studied at constant temperature. $2N_2O_5 \rightarrow 4NO_2 + O_2$

The following data was collected.

Time (s)	$[N_2O_5]$ (M)
0.0	0.1000
50	0.0707
100	0.0500
200	0.0250
300	0.0125
400	0.00625

Using your graphing calculator, determine the instantaneous rates in M/s at (a) t = 2.5 min and (b) t = 350 sec.

a._____ and b._____

4. Determine the rate law from experimental results. Calculate the rate, rate constant, or reactant concentration given two of these.

The reaction $2NO + Cl_2 \rightarrow 2NOCl$
Was studied at -10°C. The following results were obtained:

[NO] (M)	$[Cl_2]$ (M)	Initial Rate (M/s)
0.10	0.10	0.18
0.10	0.20	0.36
0.20	0.20	1.45

Express the rate law.

Calculate the magnitude of the rate constant, include units.

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5. The following data were obtained for the reaction

$2ClO_2 + 2OH^{-1} \rightarrow ClO_3^{-1} + ClO_2^{-1} + H_2O$

$[ClO_2]$ (M)	$[OH^{-1}]$ (M)	Initial Rate (M/s)
0.050	0.100	5.75×10^{-2}
0.100	0.100	2.3×10^{-1}
0.100	0.050	1.15×10^{-1}

Determine the rate law.

Calculate the value of the rate constant:

How is the rate of appearance of ClO_3^{-1} related to the rate of disappearance of OH^{-1}?

What is the rate of disappearance of OH^{-1} when $[OH^{-1}] = 0.065$ M and $[ClO_2] = 0.15$ M?

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Objective 2: Reaction Rates: First and Second Order

1. Calculate the concentration of a reactant or product at any time after a reaction has started.

The decomposition of phosphine (PH_3) is first order with respect to the reactant. It takes 120 seconds for 1.0 M PH_3 to decrease to 0.25 M. How much time is required for 2.0 M PH_3 to decrease to a concentration of 0.35 M?

2. Calculate rate constant and half-life for a first-order or second order reaction.

The rate of the reaction $NO_2 + CO \rightarrow NO + CO_2$ depends only on the concentration of nitrogen dioxide below 225 degrees Celsius. At an appropriate temperature, the following data were collected.

Time (s)	0	1200	3000	4500	9000	18000
$[NO_2]$	0.500	0.444	0.381	0.340	0.250	0.174
ln $[NO_2]$						
1/ $[NO_2]$						

Determine the rate law AND the value of the rate constant, k.

_____ and _____

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Objective 3: Factors Influencing Reaction Rates: Temperature and Activation Energy

1. The rate constant for the gas-phase decomposition of dinitrogen pentoxide,

$N_2O_5 \rightarrow 2NO_2 + \frac{1}{2} O_2$

Has the following temperature dependence:

T (K)	k (s^{-1})
338	0.0049
318	0.0005
298	.000035

From these data, calculate the activation energy using the nongraphing form of the Arrhenius equation in units of kJ/mol. Show all work.

What is the rate constant at 300 K?

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