Exercise 17.2a
Rate of Reaction

Name: _____

Date: _____ Per: _____

DIRECTIONS: Answer the following in the space provided.

1. List the five factors that affect the rate of a reaction and explain in terms of kinetic theory.
   a. _____ _____
   b. _____ _____
   c. _____ _____
   d. _____ _____
   e. _____ _____
2. Differentiate between a heterogeneous and a homogeneous catalyst.

3. How does a catalyst affect reaction rate?

4. Diagram and label a potential energy curve for a catalyzed and uncatalyzed exothermic reaction.

Determining a Rate Law by Method of Initial Rates

Rate laws are always determined experimentally. The basic format of the rate law for a particular reaction will always be:

rate = *k*[reactant 1]^{x}[reactant 2]^{y}[reactant 3]^{z}…

The exponents ^{x}, ^{y}, & ^{z} are the "reactant orders" and are the parts of the law that must be determined experimentally. Typically, the process involves running the reaction repeatedly while holding initial concentrations of all reactants, except one, constant. The one concentration that is not held constant is varied systematically (usually doubled) and the reaction rate is measured. Using this approach, the effect of the concentration on a particular reactant can be calculated. This is done for each reactant until the rate law can be derived.

Reactant orders are usually small positive integers (e.g., 0-3), but may be negative or fractions (though you won't see any of those in this course). The value of the integer may be determined by evaluating the reaction rate relative to the change in concentration. Focus on change in concentration (not actual values) & magnitude of change in rate (not actual values).

Δ[Reactant]	**0th Order [ ]^{0}**	**1st Order [ ]^{1}**	**2nd Order [ ]^{2}**	**3rd Order [ ]^{3}**
doubled	$[1]^0 = 1$, $[2]^0 = 1$	$[1]^1 = 1$, $[2]^1 = 2$	$[1]^2 = 1$, $[2]^2 = 4$	$[1]^3 = 1$, $[2]^3 = 8$
tripled	$[1]^0 = 1$, $[3]^0 = 1$	$[1]^1 = 1$, $[3]^1 = 3$	$[1]^2 = 1$, $[3]^2 = 9$	$[1]^3 = 1$, $[3]^3 = 27$
quadrupled	$[1]^0 = 1$, $[4]^0 = 1$	$[1]^1 = 1$, $[4]^1 = 4$	$[1]^2 = 1$, $[4]^2 = 16$	$[1]^3 = 1$, $[4]^3 = 64$

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5. Determine the rate law for the reaction A + B + C → D using the data below.

A + B + C → D, at constant temperature				
Trial	Initial [A]*(M)*	Initial [B]*(M)*	Initial [C]*(M)*	Rate *(M/s)*
1	0.10	0.20	0.30	0.045
2	0.20	0.20	0.30	0.090
3	0.10	0.40	0.30	0.045
4	0.10	0.20	0.60	0.18

_____ What is the overall order of the reaction? _____

6. Determine the rate law for the reaction: $2\ NO(g) + O_2(g) \rightarrow 2\ NO_2(g)$. The following data were obtained from three experiments using the method of initial rates:

	Initial [NO] *(M)*	Initial [O_2] *(M)*	Rate NO*(M/s)*
Experiment 1	0.010	0.010	2.5×10^{-5}
Experiment 2	0.020	0.010	1.0×10^{-4}
Experiment 3	0.010	0.020	5.0×10^{-5}

_____ What is the overall order of the reaction? _____

7. Determine the rate law for the reaction: $2\ NO(g) + 2\ H_2(g) \rightarrow N_2(g) + 2\ H_2O(g)$ if the data for the reaction at 904 °C, is:

	Initial [NO] *(M)*	Initial [H_2] *(M)*	Rate N_2 *(M/s)*
Experiment 1	0.420	0.122	0.136
Experiment 2	0.210	0.122	0.0339
Experiment 3	0.210	0.244	0.0678
Experiment 4	0.105	0.488	0.0339

_____ What is the overall order of the reaction? _____

8. Determine the rate law for the reaction of ᵗbutyl-bromide $(CH_3)_3CBr$ with water represented by the equation:

$$(CH_3)_3CBr + H_2O \rightarrow (CH_3)_3COH + HBr$$

The following data were obtained from three experiments using the method of initial rates:

	Initial [$(CH_3)_3CBr$] *(M)*	Initial [H_2O] *(M)*	Rate *(M/min)*
Experiment 1	5.0×10^{-2}	2.0×10^{-2}	2.0×10^{-6}
Experiment 2	5.0×10^{-2}	4.0×10^{-2}	2.0×10^{-6}
Experiment 3	1.0×10^{-1}	4.0×10^{-2}	4.0×10^{-6}

_____ What is the overall order of the reaction? _____

A reaction has the rate law, rate = $k[A]^3[B][C]^2$.

9. What happens to the reaction rate if the concentration of A is doubled? _____
10. What happens to the reaction rate if the concentration of B is doubled? _____
11. What happens to the reaction rate if the concentration of C is doubled? _____
12. What happens to the reaction rate if the concentration of A is halved? _____
13. What happens to the reaction rate if the concentration of C is tripled? _____
14. What happens to the reaction rate if the concentration of C is halved? _____