SCH4U **RATE LAW EQUATION PROBLEM SET**

Part 1: Rate Law Equation Practice

1. For a reaction where the rate equation is $r = k[NH_4^+{}_{(aq)}][NO_2^-{}_{(aq)}]$,
   a) calculate k at temperature T_1, if the rate, r, is 2.40×10^{-7} mol/(L·s) when $[NH_4^+{}_{(aq)}]$ is 0.200 mol/L and $[NO_2^-{}_{(aq)}]$ is 0.00500 mol/L. $k = 0.000240$ L/mol·s
   b) calculate r at temperature T_2, if the rate constant, k, is 3.20×10^{-4} L/(mol·s) when $[NH_4^+{}_{(aq)}]$ is 0.100 mol/L and $[NO_2^-{}_{(aq)}]$ is 0.0150 mol/L. $r = 4.80 \times 10^{-7}$ mol/L·s

2. A series of experiments is performed for the system

$$2A + 3B + C \longrightarrow D + 2E$$

- When the initial concentration of A is doubled, the rate increases by a factor of 4.
- When the initial concentration of B is doubled, the rate is doubled.
- When the initial concentration of C is doubled, there is no effect on rate.

a) What is the order of reaction with respect to each of the reactants? A is 2nd B is 1st C is ∅
b) Write an expression for the rate equation.
$r = k[A]^2[B]$

Part 2: More Rate Law Expressions

1. Consider the data for hydrogen concentration $[H_2]$, iodine concentration $[I_2]$ and rate of reaction (moles per litre per second or mol·L^{-1}/s) for this reaction:

$$H_2\,(g) + I_2\,(g) \longrightarrow 2\,HI\,(g)$$

Trial	$[H_2]$ (mol/L) 1	$[I_2]$ (mol/L) 3	Rate (mol·L^{-1}/s)	
1	0.01 ×2	0.05 c	0.04 ×2	$2^1 = 2$
2	0.02	0.05	0.08	
3	0.03	0.05	0.12	
4	0.05 c	0.01 ×2	0.02 ×8	$2^3 = 8$
5	0.05	0.02	0.16	
6	0.05	0.03	0.54	

a) Determine the rate law expression for this reaction. $r = k[H_2][I_2]^3$
b) What is the overall reaction order? 4th order
c) What would happen to the rate of the reaction if the concentration of both reactants was doubled? 16x faster

2. Consider a hypothetical reaction:

$$A + B \longrightarrow C + D$$

Doubling the concentration of A causes the reaction rate to increase by a factor of four. This is done while the concentration of B is held constant. Tripling the concentration of B, while the concentration of A is held constant, causes the reaction rate to increase by a factor of nine.

a) What is the rate law expression for this reaction? $r = k[A]^2[B]^2$
b) What would happen to the reaction rate if the concentration of A was tripled and the concentration of B was doubled simultaneously? 36x faster

3. Consider the reaction:

$$NH_4^+ (aq) + NO_2^- (aq) \longrightarrow N_2 (g) + 2 H_2O (l)$$

Experiment	$[NO_2^-]$ (mol/L) 1		$[NH_4^+]$ (mol/L) 1		Rate ($\text{mol}\cdot L^{-1}/s \times 10^{-7}$)		
1	0.0100	x2	0.200	c	5.4	x2	$2^1=2$
2	0.0200		0.200		10.8		
3	0.0400		0.200		21.6		
4	0.200	c	0.0202	x2	10.8	x2	$2^1=2$
5	0.200		0.0404		21.6		
6	0.200		0.0606		32.4		

Determine the rate law expression for this reaction. $r=k[NO_2^-][NH_4^+]$

4. Consider a hypothetical reaction:

$$A + B \longrightarrow C$$

Experiment		[A] (mol/L) 2			[B] (mol/L) 0			Rate ($\text{mol}\cdot L^{-1}/s \times 10^{-5}$)		
1	x2	0.100	c	c	0.100	x2	x4	4.0	1	$2^0=1$
2		0.100			0.200			4.0		$2^2=4$
3		0.200			0.100			16.0		

a) Determine the rate law expression for this reaction. $r=k[A]^2$

b) What is the order of reaction with respect to A? to B? A = 2nd order B = Ø order

c) What is the overall reaction order? 2nd order

5. In a reaction involving only one reactant, A, the rate of the reaction increases by a factor of 27 when the concentration of A is tripled. What is the rate law expression for this reaction? $r=k[A]^3$

6. A + B $\longrightarrow$ C + D $r = k[A]^2[B]^2$

The rate of the reaction is 1.0×10^{-4} M/s when the concentration of A is 0.40 M and the concentration of B is 0.30 M. Calculate the rate of the reaction when the concentration of A is 0.85 M and the concentration of B is 0.75 M. Find k first. $k = 6.94 \times 10^{-3}\ L^3/mol^3\cdot s$ $r = 2.82 \times 10^{-3}\ mol/L\cdot s$

7. A + B $\longrightarrow$ C $r = k[A]^2[B]^0$

The rate of the reaction is 4.0×10^{-5} M/s when the concentration of A is 0.100 M. Calculate the rate of the reaction when the concentration of A is 0.550 M. $k = 0.004\ L/mol\cdot s$ $r = 1.21 \times 10^{-3}\ mol/L\cdot s$

8. 2HI $\longrightarrow$ H_2 + I_2 $r = k[HI]^2$

The rate of reaction is 2.5×10^{-4} M/s when the concentration of HI is 0.0588 M. Calculate the new rate of reaction if the concentration of HI is 0.0885 M. $k = 7.21 \times 10^{-2}\ L/mol\cdot s$ $r = 5.64 \times 10^{-4}\ mol/L\cdot s$

9. The decomposition of N_2O_5 has the rate law: $r = k[N_2O_5]$.

If $k = 1.0 \times 10^{-5}$ 1/s, what is the rate of the reaction when the concentration of N_2O_5 is 0.0010 M? $r = 1 \times 10^{-8}\ \frac{mol}{L\cdot s}$