SCH4U

Answers: Rates of Reactions Practice Questions

Rate Laws:

1. $2NO_{(g)} + H_{2(g)} \rightarrow N_2O_{(g)} + H_2O_{(g)}$

Initial Concentration (mol/L)		Initial Rate (mol/L.s)
$NO_{(g)}$	$H_{2(g)}$	
0.075	0.400	0.005
0.150	0.200	0.010
0.150	0.400	0.020

a) Find the rate law. Rate = $k[NO]^2[H_2]$

b) Determine the value of the rate constant.

$0.005 = k\,(0.075)^2(0.400)$

$K = 2.22\ L^2/mol^2{\cdot}s$

2. $NH_4^+{}_{(aq)} + NO_2^-{}_{(aq)} \rightarrow N_{2(g)} + 2H_2O_{(l)}$

Initial Concentration (mol/L)		Initial Rate (mol/L.s)
$NO_2^-{}_{(aq)}$	$NH^+{}_{(aq)}$	
0.010	0.020	5.4×10^{-7}
0.020	0.020	10.8×10^{-7}
0.040	0.020	21.6×10^{-7}
0.020	0.0202	10.8×10^{-7}
0.020	0.0404	21.6×10^{-7}
0.020	0.0606	32.4×10^{-7}

a) Write the rate law. Rate = $k[NO_2][NH_4^+]$

b) Calculate the rate constant.

$5.4 \times 10^{-7} = k(0.01)(0.02)$

$K = 0.0027\ L/mol{\cdot}s$

c) Calculate the initial rate if $[NO_2^-{}_{(aq)}] = 0.10$ M and $[NH^+{}_{(aq)}] = 0.10$M.

Rate = 0.0027(0.10)(0.10)

Rate = 2.7×10^{-5} mol/L·s

3. $4OH_{(g)} + H_2S_{(g)} \rightarrow SO_{2(g)} + 2H_2O_{(g)} + H_{2(g)}$

Initial Concentration (mol/L)		Rate of Disappearance of H_2S(mol/L.s)
$OH_{(g)}$	$H_2S_{(g)}$	
1.3×10^{-8}	2.1×10^{-8}	1.4×10^{-6}
3.9×10^{-8}	2.1×10^{-8}	4.2×10^{-6}
3.9×10^{-8}	4.2×10^{-8}	8.4×10^{-6}

a) Write the rate law. Rate = k[OH][H_2S]

b) Calculate the rate constant.

$1.4 \times 10^{-6} = k(1.3 \times 10^{-8})(2.1 \times 10^{-8})$

$K = 5.1 \times 10^{9}$ L/mol·s

c) Calculate the rate of disappearance of H_2S when [$OH_{(g)}$] = 1.7×10^{-8} M and [$H_2S_{(g)}$] = 1.0×10^{-8} M. What is the rate of disappearance of OH at the same time?

Rate = $5.1 \times 10^{9}(1.7 \times 10^{-8})(1.0 \times 10^{-8})$

Rate = 8.7×10^{-7} mol/L·s

Rate of disappearance of OH at the same time is $4(8.7 \times 10^{-7}) = 3.5 \times 10^{-6}$ mol/L.s

4. The rate law for the reaction: A + B + 2C → D + E is rate = $k[A]^2[C]$.

a) Complete the chart.

Experiment	[A] (mol/L)	[B] (mol/L)	[C] (mol/L)	Initial rate (mol/L.min)	K
1	1.0	4.0	2.0	8.0	4.0
2	2.0	2.0	1.0	16	4.0

b) How can the rate constant be increased? Increase temperature

Mechanisms and Rate Laws:

5. The mechanism for a reaction is:

$NO_2Cl \rightarrow NO_2 + Cl$ (slow)

$NO_2Cl + Cl \rightarrow NO_2 + Cl_2$ (fast)

a) What is the overall reaction? $2NO_2Cl \rightarrow 2NO_2 + Cl_2$

b) What is the reaction intermediate? Cl

c) What is the rate law? Rate = k[NO_2Cl]

6. If a mechanism for a reaction is:

A + B → C + D (slow)

D + A → F + F (fast)

a) If the first step is the rate-determining step, which step is the fast step? Second step

b) Write the rate law for the reaction. Rate = k[A][B]

c) What is the overall reaction? 2A + B → C + 2F

7. For the reaction of:

$$H_2O_2 + 2H^+ + 2I^- \rightarrow I_2 + 2H_2O$$

A proposed mechanism is:

$H_2O_2 + I^- \rightarrow H_2O + OI^-$	(slow)
$H^+ + OI^- \rightarrow HOI$	(rapid)
$HOI + H^+ + I^- \rightarrow I_2 + H_2O$	(rapid)

For this mechanism to be consistent with the experimental data, what must the observed rate law be?

Rate = $k[H_2O_2][I^-]$

8. At low pressure, the reaction:

$$2NO_2 + F_2 \rightarrow 2NO_2F$$

Follows the rate law: Rate = $k[NO_2][F_2]$

Suggest a mechanism that is consistent with the rate law.

$NO_2 + F_2 \rightarrow NO_2F_2$ (slow)
$NO_2 + NO_2F_2 \rightarrow 2NO_2F$ (fast)

9. For the reaction: $2A + B \rightarrow C$, the rate of formation of C was measured for a number of different initial concentrations of A and B, with the following results:

Initial Concentration (mol/L)		Rate of Appearance of C (mol/L.s)
A	B	
0.10	0.10	2.0×10^{-3}
0.20	0.10	8.0×10^{-3}
0.30	0.10	1.8×10^{-2}
0.20	0.20	8.0×10^{-3}
0.30	0.30	1.8×10^{-2}

a) Write the rate law. Rate = $k[A]^2$
b) Calculate the rate constant. K = 0.20 L/mol·s
c) Suggest a two-step mechanism that is consistent with the experimental data.
$2A \rightarrow D$ (slow)
$D + B \rightarrow C$ (fast)

10. For the reaction: $I^- + OCl^- \rightarrow Cl^- + OI^-$, the following data was collected:

Initial Concentration (mol/L)		Rate of Production of Cl^- (mol/L.s)
I^-	OCl^-	
0.10	0.10	1.0×10^{-3}
0.20	0.10	2.0×10^{-3}
0.30	0.30	9.0×10^{-3}
0.30	0.60	1.8×10^{-2}

a) Write the rate law. Rate = $k[I^-][OCl^-]$
b) Calculate the rate constant. K = 0.10 L/mol·s
c) Suggest a two-step mechanism that is consistent with the experimental data.

$I^- + OCl^- \rightarrow IOCl^{2-}$ (slow)
$IOCl^- \rightarrow Cl^- + OI^-$ (fast)

11. The reaction: $NO_2 + CO \rightarrow CO_2 + NO$ is known to be a one-step reaction at very high temperatures. At a much lower temperature, the following data was collected:

Initial Concentration (mol/L)		Rate of Production of CO_2 (mol/L.s)
NO_2	CO	
0.010	0.010	2.1×10^{-8}
0.020	0.020	8.4×10^{-8}
0.040 ×2	0.020 ×2	×4 3.36×10^{-7} ×4
0.020	0.040	8.4×10^{-8}

a) Write the rate law. Rate = $k[NO_2]^2$
b) Calculate the rate constant. K = 2.1×10^{-4} L/mol·s
c) Suggest a two-step mechanism that is consistent with the experimental data.
$2NO_2 \rightarrow N_2O_4$ (slow)
$N_2O_4 + CO \rightarrow CO_2 + NO + NO_2$ (fast)