ample:

Initial concentration and rate data for the reaction

$2\,NO(g) + O_2(g) \longrightarrow 2\,NO_2(g)$

Experiment	Initial [NO]	Initial $[O_2]$	Initial Rate of For (M/s)
1	0.015	0.015	0.048
2	0.030	0.015	0.192
3	0.015	0.030	0.096
4	0.030	0.030	0.384

$$\text{Rate} = k[NO]^n[O_2]^m$$

$$\frac{2}{1} = \frac{.192}{0.048} = \frac{k[0.030]^n[0.015]^m}{k[0.015]^n[0.015]^m}$$

$$4 = 2^n$$

$$n = 2$$

$$\frac{4}{2} = \frac{.384}{.192} = \frac{k[0.030]^n[0.030]^m}{k[0.030]^n[0.015]^m}$$

$$2 = 2^n$$

$$n = 1$$

$$\text{Rate} = k[NO]^2[O_2]^1$$

$$0.048\ \frac{M}{s} = k[0.015]^2[0.015]^1$$

$$k = 1.4 \times 10^4\ \frac{1}{M^2 s} \qquad \frac{M}{s} \cdot \frac{1}{M^3} = \frac{1}{M^2 s}$$

$$\text{Rate} = 1.4 \times 10^4\ 1/M^2 s\,[NO]^2[O_2]$$

Example:

Experiment	Initial $[CH_3COCH_3]$	Initial Rate of Decomposition of CH_3COCH_3 (M/s)
1	6.0×10^{-3}	5.2×10^{-5}
2	9.0×10^{-3}	7.8×10^{-5}

$$\frac{7.8 \times 10^{-5}}{5.2 \times 10^{-5}} = \frac{k[9.0 \times 10^{-3}]^n}{k[6.0 \times 10^{-3}]^n}$$

$$1.5 = 1.5^n$$

$$n = 1$$

$$\text{Rate} = k[CH_3COCH_3]$$

$$5.2 \times 10^{-5} = k(6.0 \times 10^{-3})$$

$$k = 0.0087\ 1/s$$

$$\text{Rate} = 0.0087\ 1/s\,[CH_3COCH_3]$$

Example:

Experiment	Initial $[CH_3NNCH_3]$	Initial Rate of Decomposition of CH_3NNCH_3 (M/s)
1	2.4×10^{-2}	6.0×10^{-6}
2	8.0×10^{-3}	2.0×10^{-6}

$$\frac{6.0 \times 10^{-6}}{2.0 \times 10^{-6}} = \frac{k[2.4 \times 10^{-2}]^n}{k[8.0 \times 10^{-3}]^n}$$

$$3 = 3^n$$

$$n = 1$$

$$\text{Rate} = k[CH_3NNCH_3]$$

$$6.0 \times 10^{-6} = k(2.4 \times 10^{-2})$$

$$k = 2.5 \times 10^{-4}\ 1/s$$

$$\text{Rate} = 2.5 \times 10^{-4} s^{-1}\,[CH_3NNCH_3]$$

Example:

Experiment	Initial $[NH_4^+]$	Initial $[NO_2^-]$	Initial Rate of Consumption of NH_4^+ (M/s)
1	0.24	0.10	7.2×10^{-6}
2	0.12	0.10	3.6×10^{-6}
3	0.12	0.15	5.4×10^{-6}

$\frac{7.2 \times 10^{-6}}{3.6 \times 10^{-6}} = \frac{k[.24]^n}{k[.12]^n}$

$2 = 2^n$

$n = 1$

$\frac{5.4 \times 10^{-6}}{3.6 \times 10^{-6}} = \frac{k[.15]^m}{k[.10]^m}$

$1.5 = 1.5^n$

$n = 1$

$\text{Rate} = k[NH_4^+][NO_2^-]$

$7.2 \times 10^{-6} \frac{M}{s} = k(.24M)(.10M)$

$k = 3.0 \times 10^{-4}\ M^{-1}s^{-1}$

$\text{Rate} = 3.0 \times 10^{-4} M^{-1}s^{-1}[NH_4^+][NO_2^-]$

Example:

Experiment	Initial [NO]	Initial $[Cl_2]$	Initial Rate of Consumption of Cl_2 (M/s)
1	0.13	0.20	1.0×10^{-2}
2	0.26	0.20	4.0×10^{-2}
3	0.13	0.10	5.0×10^{-3}

$\frac{4.0 \times 10^{-2}}{1.0 \times 10^{-2}} = \frac{k[.26]^n}{k[.13]^n}$

$4 = 2^n$

$n = 2$

$\frac{1.0 \times 10^{-2}}{5.0 \times 10^{-3}} = \frac{k[.20]^m}{k[.10]^m}$

$2 = 2^m$

$m = 1$

$\text{Rate} = k[NO]^2[Cl_2]$

$1.0 \times 10^{-2} = k[.13]^2[.20]$

$k = 3.0\ M^{-2}s^{-1}$

$\text{Rate} = 3.0 M^{-2}s^{-1}[NO]^2[Cl_2]$

Example:

Experiment	Initial $[C_2H_4Br_2]$	Initial $[I^-]$	Initial Rate of Formation of I_3^- (M/s)
1	0.127	0.102	6.45×10^{-5}
2	0.343	0.102	1.74×10^{-4}
3	0.203	0.125	1.26×10^{-4}

$\frac{1.74 \times 10^{-4}}{6.45 \times 10^{-5}} = \frac{k[.343]^n}{k[.127]^n}$

$2.70 = 2.70^n$

$n = 1$

$\frac{1.74 \times 10^{-4}}{1.26 \times 10^{-4}} = \frac{k[.343]^1[.102]^m}{k[.203]^1[.125]^m}$

$1.38 = 1.09(.816)^m$

$.816 = .816^m$

$m = 1$

$6.45 \times 10^{-5} = k[C_2H_4Br_2][.102]$

$k = 0.00498\ M^{-1}s^{-1}$

$\text{Rate} = 0.00498 M^{-1}s^{-1}[C_2H_4Br_2][I^-]$

$\text{Rate} = k[C_2H_4Br_2][I^-]$

Worksheet 12.3 – Rate Law Problems

NAME: _____

Determine the order of a reaction, with respect to the reactants: A, B, and C.

Reaction 1:

Initial [A] (mol/L)	Initial [B] (mol/L)	Initial [C] (mol/L)	Initial Rate (mol/L*s)
0.500	0.675	0.300	0.0043
1.000	0.675	0.300	0.0172
1.000	2.025	0.300	0.0516
1.000	0.675	0.150	0.0086
0.500	0.675	0.600	0.0086

What is the reaction order, with respect to A? 2

What is the reaction order, with respect to B? 1

What is the reaction order, with respect to C? 1

What is the reaction order of the overall reaction? 4

Write the rate law expression for this reaction. Rate = $0.0849 \frac{1}{M^3 s} [A]^2 [B] [C]$

Reaction 2:

Initial [A] (mol/L)	Initial [B] (mol/L)	Initial [C] (mol/L)	Initial Rate (mol/L*s)
0.86	0.75	0.50	00.8765
0.43	0.75	0.50	00.4383
0.43	2.25	0.50	11.8340
0.43	2.60	0.85	13.6474
0.86	0.75	1.00	03.5061

What is the reaction order, with respect to A? 1

What is the reaction order, with respect to B? 3

What is the reaction order, with respect to C? 2

What is the reaction order of the overall reaction? 6

Write the rate law expression for this reaction. Rate = $9.7 M^{-5} s^{-1} [A][B]^3 [C]^2$

Dete

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Reaction 1

A

$\frac{0.0172}{0.0043} = \frac{[1.0]^n}{[.5]^n}$

$4 = 2^n$

$n = 2$

B

$\frac{.0516}{0.0172} = \frac{[2.025]^m}{[0.675]^m}$

$3 = 3^m$

$m = 1$

C

$\frac{0.0086}{0.0043} = \frac{[.600]^p}{[.300]^p}$

$2 = 2^p$

$p = 1$

Total reaction order = 4

Rate = $k[A]^2[B][C]$

$0.0043\ M/s = k[.500]^2[.675]^1[.300]^1$

$0.0043\ M/s = k\ 0.0506\ M^4$

$0.0849\ 1/M^3s = k$

Rate = $0.0849\ 1/M^3s\ [A]^2[B][C]$

Reaction 2

A

$\frac{.8765}{.4383} = \frac{k[.86]^n}{k[.43]^n}$

$2 = 2^n$

$n = 1$

B

$\frac{11.8340}{0.4383} = \frac{k[2.25]^m}{k[.75]^m}$

$26.999 = 3^m$

$m = 3$

C

~~[illegible]~~

$\frac{3.5061}{.8765} = \frac{k[1.00]^p}{k[.5]^p}$

$4 = 2^p$

$p = 2$

$.8765 = k[.86][.75]^3[.5]^2$

$k = 9.663\ M^{-5}s^{-1}$

$\frac{M}{s} = M^6$

Rate = $9.663\ M^{-5}s^{-1}[A][B]^3[C]^{.25}$

Worksheet 12.4 – More Rate Law Problems

NAME: _____

Determine the order of a reaction, with respect to the reactants: A, B, and C.

Reaction 1:

Initial [A] (mol/L)	Initial [B] (mol/L)	Initial [C] (mol/L)	Initial Rate (mol/L*s)
0.34	0.78	0.12	0.056
0.34	0.39	0.12	0.056
0.34	0.39	0.24	0.448
0.34	0.67	0.56	0.857
0.68	0.78	0.12	0.112

What is the reaction order, with respect to A? 1

What is the reaction order, with respect to B? Is that so? 0

What is the reaction order, with respect to C? 3

What is the reaction order of the overall reaction? 4

Write the rate law expression for this reaction. $Rate = 95 M^{-3} s^{-1} [A][C]^3$

Reaction 2:

Initial [A] (mol/L)	Initial [B] (mol/L)	Initial [C] (mol/L)	Initial Rate (mol/L*s)
0.12	0.6	0.3	02.5
0.12	1.2	0.3	05.0
0.12	1.2	0.9	45.0
0.12	2.4	1.8	90.5
0.36	0.6	0.3	22.5

What is the reaction order, with respect to A? 2

What is the reaction order, with respect to B? 1

What is the reaction order, with respect to C? 2

What is the reaction order of the overall reaction? 5

Write the rate law expression for this reaction. $Rate = 3000 M^{-4} s^{-1} [A]^2 [B] [C]^2$

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(1)

A

$\frac{.112}{.056} = \frac{[.68]^n}{[.34]^n}$

$2 = 2^n$

$n = 1$

B

$\frac{.056}{.056} = \frac{[.78]^m}{[.39]^m}$

$1 = 2^m$

$m = 0$

C

$\frac{.448}{.056} = \frac{[.24]^p}{[.12]^p}$

$8 = 2^p$

$p = 3$

$Rate = k[A]^1[C]^3$

$0.056 = k[.34][.12]^3$

$k = 95\ M^{-3}s^{-1}$

$Rate = 95\ M^{-3}s^{-1}[A][C]^3$

(2)

A

$\frac{22.5}{2.5} = \frac{[.36]^n}{[.12]^n}$

$9 = 3^n$

$n = 2$

B

$\frac{5.0}{2.5} = \frac{[1.2]^m}{[.6]^m}$

$2 = 2^m$

$m = 1$

C

$\frac{45.0}{5.0} = \frac{[.9]^p}{[.3]^p}$

$9 = 3^p$

$p = 2$

$Rate = k[A]^2[B][C]^2$

$2.5 = k[.12]^2[.6][.3]^2$

$K = 3215\ M^{-4}s^{-1}$

$Rate = 3215\ M^{-4}s^{-1}[A]^2[B][C]^2$