Worksheet 12.5a Rates of reaction Name________________________

1. The following data were obtained for the reaction $2\,NO + O_2 \rightarrow 2\,NO_2$:

Experiment	$[NO]_0$	$[O_2]_0$	Initial rate, v_0 ($mol\ L^{-1}\ s^{-1}$)
1	0.12 M	0.05 M	0.12
2	0.12 M	0.10 M	0.24
3	0.24 M	0.05 M	0.48

(a) Write the rate law for the reaction. Explain your reasoning in arriving at your rate law.

NO

$\frac{.48}{.12} = \frac{k[.24]^n}{k[.12]^n}$

$4 = 2^n$

$n = 2$

O_2

$\frac{.24}{.12} = \frac{[.10]^m}{[.05]^m}$

$2 = 2^m$

$m = 1$

Rate $= k[NO]^2[O_2]$

(b) What is the overall order of the reaction?

3rd

(c) Determine the value of the rate constant.

$.12 = k[.12]^2[0.05]$

$k = 167\ M^{-2}s^{-1}$

2. The following data were obtained for the reaction A + B + C → *products*:

Experiment	$[A]_0$	$[B]_0$	$[C]_0$	Initial rate, v_0 ($mol\ L^{-1}\ s^{-1}$)
1	1.25×10^{-3} M	1.25×10^{-3} M	1.25×10^{-3} M	0.0087
2	2.50×10^{-3} M	1.25×10^{-3} M	1.25×10^{-3} M	0.0174
3	1.25×10^{-3} M	3.02×10^{-3} M	1.25×10^{-3} M	0.0508
4	1.25×10^{-3} M	3.02×10^{-3} M	3.75×10^{-3} M	0.457
5	3.01×10^{-3} M	1.00×10^{-3} M	1.15×10^{-3} M	?

(a) Write the rate law for the reaction. Explain your reasoning in arriving at your rate law.

$\boxed{\text{Rate} = k[A][B]^2[C]^2}$

[A]

$\frac{.0174}{.0087} = \frac{[2.5 \times 10^{-3}]^n}{[1.25 \times 10^{-3}]^n}$

$2 = 2^n$

$n = 1$

[B]

$\frac{.0508}{.0087} = \frac{(3.02 \times 10^{-3})^m}{[1.25 \times 10^{-3}]^m}$

$5.84 = 2.416^m$

3 $m = 2$

[C]

$\frac{.457}{.0508} = \frac{[3.75 \times 10^{-3}]^p}{[1.25 \times 10^{-3}]^p}$

$9 = 3^p$

$p = 2$

(b) What is the overall order of the reaction?

5th

(c) Determine the value of the rate constant.

$.0087 = k[1.25\times10^{-3}][1.25\times10^{-3}]^2[1.25\times10^{-3}]^2$

$k = 2.85\times10^{12}\ M^{-4}s^{-1}$

(d) Use the data to predict the reaction rate for experiment 5.

$Rate = (2.85\times10^{12}\ M^{-4}s^{-1})(3.01\times10^{-3})(1.00\times10^{-3})^2(1.15\times10^{-3})^2$

Rate = 0.0113 M/s

3. The following data were obtained for the reaction A + B + C → *products*:

Experiment	$[A]_0$ (M)	$[B]_0$ (M)	$[C]_0$ (M)	Initial rate, v_0 (mol L^{-1} s^{-1})
1	0.100	0.100	0.100	0.100
2	0.200	0.100	0.100	~~0.008~~ .800
3	0.200	0.300	0.100	7.200
4	0.100	0.100	0.400	0.400

(a) Write the rate law for the reaction. Explain your reasoning in arriving at your rate law.

A

$\frac{.100}{\cancel{.008}\ .800} = \frac{[.100]^n}{[.200]^n}$

$.125 = .5^n$

$\boxed{n = 3}$

B

$\frac{7.200}{\cancel{.008}\ .800} = \frac{[.300]^m}{[.100]^m}$

$9 = 3^m$

$\boxed{m = 2}$

C

$\frac{.100}{.400} = \frac{[.100]^p}{[.400]^p}$

$.25 = .25^p$

$p = 1$

$Rate = k[A]^3[B]^2[C]$

(b) What is the overall order of the reaction?

6th

(c) Determine the value of the rate constant.

$.100 = k[.100]^3[.100]^2[.100]$

$k = 1.00\times10^5\ M^{-5}s^{-1}$

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Name: ______________________ Date: ______________________ Class Pd. ____

AP Chemistry Kinetics Classwork

1. The following data was determined experimentally for the reaction below.

$$O_2\ (g) + 2NO \rightarrow 2NO_2\ (g)$$

$[O_2]$	[NO]	initial rate (M/s)
1.10×10^{-2}	1.30×10^{-2}	3.21×10^{-3}
2.20×10^{-2}	1.30×10^{-2}	6.40×10^{-3}
1.10×10^{-2}	2.60×10^{-2}	12.8×10^{-3}
3.30×10^{-2}	1.30×10^{-2}	9.60×10^{-3}
1.10×10^{-2}	3.90×10^{-2}	28.8×10^{-3}

a) Determine the rate law

$[O_2]$

$$\frac{6.40\times10^{-3}}{3.21\times10^{-3}} = \frac{(2.20\times10^{-2})^n}{(1.10\times10^{-2})^n}$$

$2 = 2^n$

$n = 1$

[NO]

$$\frac{28.8\times10^{-3}}{12.8\times10^{-3}} = \frac{[3.90\times10^{-2}]^m}{[2.60\times10^{-2}]^m}$$

$2.25 = 1.5^m$

$m = 2$

$Rate = k[O_2][NO]^2$

b) Calculate the value for k

$3.21\times10^{-3} = k(1.10\times10^{-2})(1.30\times10^{-2})^2$

$k = 1730\ M^{-2}s^{-1}$

c) Calculate the rate of the reaction when the concentration of oxygen is 4.00×10^{-3} M and the concentration of NO is 3.00×10^{-3}M.

$Rate = (1730\ M^{-2}s^{-1})(4.00\times10^{-3}\ M)(3.00\times10^{-3}\ M)^2$

$Rate = 6.23\times10^{-5}\ M/s$

2. Based on the following reaction profile

a. How many intermediates are formed in the reaction A → C? 2

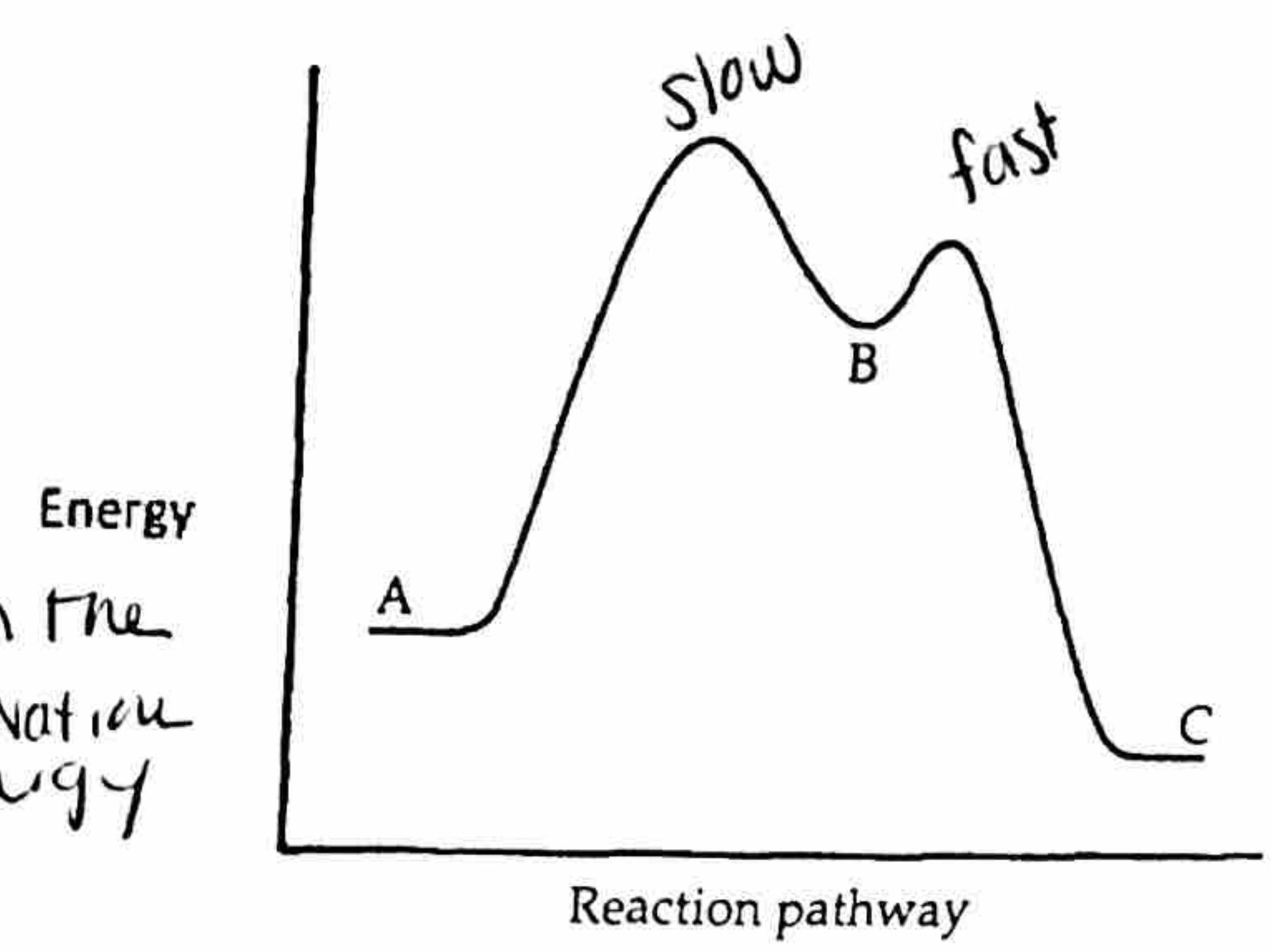
b. How many activated complexes are there? 2

c. Which step is the fastest? 2nd

* the one with the lower activation energy

d. Is the reaction exothermic or endothermic?

exothermic

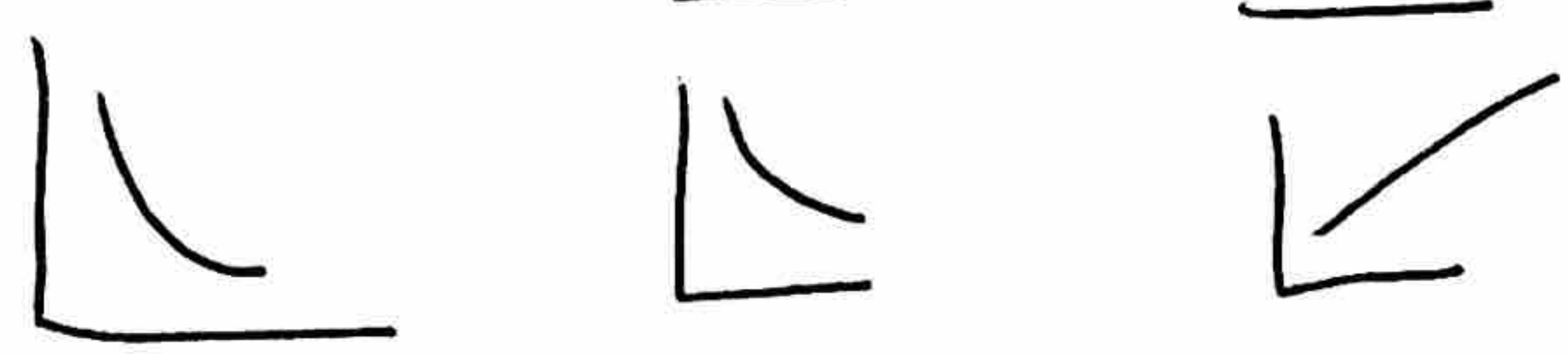


The rate of the reaction $NO_2(g) + CO(g) \rightarrow NO(g) + CO_2(g)$ Depends only on the concentration of nitrogen dioxide below 225°C. At a temperature below 225°C the following data were collected:

*graph b/c integrate (time vs concentration)

Time (s)	$[NO_2]$ (mol/L)
0	0.500
1.20×10^3	0.444
3.00×10^3	0.381
4.50×10^3	0.340
9.00×10^3	0.250
1.80×10^4	0.174

0 1st 2nd



a. Determine the rate law

Rate = $k[NO_2]^2$

b. Determine the integrated law

$$\frac{1}{[NO_2]} = kt + \frac{1}{[NO_2]_0}$$

c. Determine the value of the rate constant.

$k = 2.10 \times 10^{-4}\ M^{-1}s^{-1}$ slope

d. Calculate $[NO_2]$ at 2.70×10^4 s after the start of the reaction.

$$\frac{1}{x} = (2.10 \times 10^{-4})(2.70 \times 10^4) + \frac{1}{.500}$$

$\boxed{x = .130\ M}$

3. A proposed mechanism for a reaction is

$C_4H_9Br \longrightarrow \cancel{C_4H_9^+} + Br^-$ Slow

$\cancel{C_4H_9^+} + H_2O \longrightarrow \cancel{C_4H_9OH_2^+}$ Fast

$\cancel{C_4H_9OH_2^+} + H_2O \longrightarrow C_4H_9OH + H_3O^+$ Fast

a. Write the rate law expected for this mechanism Rate = $k[C_4H_9Br]$

b. What is the overall balanced equation? $C_4H_9Br + 2H_2O \rightarrow Br^- + C_4H_9OH + H_3O^+$

c. Identify the reaction intermediates in the mechanism.

$C_4H_9^+$, $C_4H_9OH_2$