

## Kinetics Problems

You should be able to do these problems without a calculator.

- 1) The rate equation for the reaction:  $2\text{NO}(g) + 2\text{H}_2(g) \longrightarrow \text{N}_2(g) + 2\text{H}_2\text{O}(g)$  is second order in  $\text{NO}(g)$  and first order in  $\text{H}_2(g)$ .
- a) Write an equation for  $\frac{d[\text{N}_2]}{dt}$ . ( $\frac{d[\text{N}_2]}{dt} = k[\text{NO}]^2[\text{H}_2]$ )
- b) If concentrations are expressed in molarity, what units would the rate constant,  $k$ , have? ( $\text{M}^2\text{s}^{-1}$ )
- c) Write an equation for  $-\frac{d[\text{NO}]}{dt}$ . Would  $k$  in this equation have the same numerical value as  $k$  in the equation of part (a)? ( $-\frac{d[\text{NO}]}{dt} = 2k[\text{NO}]^2[\text{H}_2]$ , yes)

- 2) For a reaction in which A and B combine to form C, the following data were obtained:

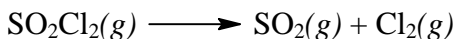
<u>measured reaction rate (mol/L-s)</u>	<u>[A] (mol/L)</u>	<u>[B] (mol/L)</u>
0.0009	0.30	0.15
0.0036	0.60	0.30
0.0009	0.15	0.30

- a) What is the rate law for the reaction? (**rate =  $k[\text{A}][\text{B}]$** )
- b) What is the numerical value of and units for the rate constant,  $k$ ? ( **$2.0 \times 10^{-2} \text{M}^{-1}\text{s}^{-1}$** )
- 3) The following (hypothetical) data were obtained for the hydrolysis of “compound A” (for the reaction  $\text{A} \longrightarrow \text{products}$ ):

<u>t(h)</u>	<u>[A], M</u>
1.00	1.00
3.00	0.500
7.00	0.250
15.0	0.125
31.0	0.0625

- a) Show graphically that this (hypothetical) hydrolysis of “compound A” follows second order kinetics.
- b) Evaluate the rate constant for the hydrolysis ( **$0.50 \text{M}^{-1}\text{hr}^{-1}$** )
- c) What was the starting concentration of “Compound A”? (**2.00 M**)
- d) What was the initial rate of reaction? (**2.00 M/hr**)
- e) How many hours would it take to hydrolyze 80% of the original sample? (**4**)
- f) What is the half-life for the reaction after 31 hours have elapsed? (**32 hours**)

4) A study of the reaction



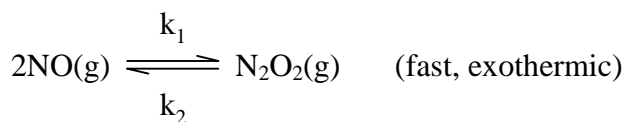
at 593 K shows that it is first order and that 75.0% of the  $\text{SO}_2\text{Cl}_2$  decomposes in 23.0 minutes.

- Calculate **k** for the reaction at 593 K. ( **$6 \times 10^{-2} \text{ min}^{-1}$** )
- How many minutes will it take for a 5.00 mmol sample of  $\text{SO}_2\text{Cl}_2$  to decompose to 3.00 mmol? (**8.5**)

*Note: To do this question without a calculator you will need to know that  $\ln(10)$  is 2.3, and the following:*

$x$	$\log(x)$
2	0.30
3	0.48
4	0.60
5	0.70
6	0.78
7	0.85
8	0.90
9	0.95

5) A proposed mechanism for the reaction of NO with  $\text{O}_2$  is as follows:



- What is the overall reaction? ( **$2\text{NO}(\text{g}) + \text{O}_2(\text{g}) \longrightarrow 2\text{NO}_2(\text{g})$** )
  - Which species is or are reactive intermediates? ( **$\text{N}_2\text{O}_2$** )
  - Which species is or are catalysts? (**none**)
  - Which step or steps are termolecular? (**none**)
  - Which step will have the smallest activation energy? (**1, forward**)
  - Which step will be most affected by temperature changes? (**2**)
  - What is the rate law predicted by this mechanism? ( **$\text{rate} = k_1 k_3 / k_2 [\text{NO}]^2 [\text{O}_2]$** )
  - What is the overall order of the rate law predicted by this mechanism? (**3**)
- 6) The rate of a certain reaction increases by a factor of ten when it is carried out at is increased from 300 K to 383 K. What is the activation energy of the reaction? (**about 26 kJ/mol**)