3.091: Introduction to Solid State Chemistry
Fall 2018
Practice Problems J: Kinetics & reactions

Reading: Averill 14.1-14.5; 13.1-13.3; 17.1; 17.4

1. Rate laws and reaction order

Averill Chapter 14, Section 3, Numerical Problem 1

Iodide reduces Fe(III) according to the following reaction:

$$2Fe^{3+}_{aq} + 2I^{-}_{aq} \rightarrow 2Fe^{2+}_{aq} + 2I_{aq}$$

Experimentally, it was found that doubling the concentration of Fe(III) doubled the reaction rate, and doubling the iodide concentration increased the reaction rate by a factor of 4. What is the reaction order with respect to each species? What is the overall rate law? What is the overall reaction order?

2. Rate law and reaction order from experimental data

Averill Chapter 14, Section 3, Numerical Problem 2

Benzoyl peroxide is a medication used to treat acne. Its rate of thermal decomposition at several concentrations was determined experimentally, and the data were tabulated as follows:

Experiment	[Benzoyl Peroxide]$_0$ (M)	Initial Rate (M/s)
1	1.00	$2.22 \times 10^{-}4$
2	0.70	1.64×10^{-4}
3	0.50	1.12×10^{04}
4	0.25	0.59×10^{-4}

What is the reaction order with respect to benzoyl peroxide? What is the rate law for this reaction?

3. Determine whether it's a first-order process

Averill Chapter 14, Section 5, Numerical Problem 1 Half-lives for the reaction A + B C were calculated at three values of [A]$_0$, and [B] was the same in all cases. The data are listed in the following table: Does this

[A]$_0$ (M)	$t_{1/2}$ (s)
0.50	420
0.75	280
1.0	210

reaction follow first-order kinetics? On what do you base your answer?

4. Rate constant and reaction rate at different temperatures

Averill Chapter 14, Section 7, Numerical Problem 4 An enzyme-catalyzed reaction has an activation energy of 15 kcal/mol. How would the value of the rate constant differ between 20°C and 30°C? If the enzyme reduced the E_a from 25 kcal/mol to 15 kcal/mol, by what factor has the enzyme increased the reaction rate at each temperature?

5. Activation energy from experimental data

Averill Chapter 14, Section 7, Numerical Problem 5

The data in the following table are the rate constants as a function of temperature for the dimerization of 1,3-butadiene. What is the activation energy for this reaction?

T (K)	k (M^{-1}*min^{-1})
529	1.4
560	3.7
600	25
645	82

6. Impact of Cl on atmospheric ozone depletion

Averill Chapter 14, Section 9, Numerical Problem 11

At higher altitudes ozone is converted to O_2 by the reaction $O + O_3 \rightarrow 2\ O_2$, with a rate contant at 220 K of 6.8×10^{-16} cm^3*$molecule^{-1}$*s^{-1}.

a) What is the overall reaction order?

b) What is E_a for this reaction if A=8×10^{-12} cm^3*$molecule^{-1}s^{-1}$?

If Cl is present, the rate constant at 220 K becomes 3.7×10^{-11} cm^3*$molecule^{-1}$*s^{-1}, with A= 4.7×10^{-11} cm^3*$molecule^{-1}$*s^{-1}.

c) Calculate E_a for the depletion of ozone in the presence of Cl.

d) Show an energy-level diagram for these two processes, clearly labeling reactants, products, and activation energies.

e) If you were an environmental scientist using these data to explain the effects of Cl on ozone concentration, what would be your conclusions?

7. Reaction rate, half life, and decomposition time

The decomposition of hydrogen peroxide, H_2O_2, can be represented by the following reaction:

$$2H_2O_2(aq) \rightarrow H_2O(l) + O_2(g)$$

The table below reports data taken at room temperature (300 K).

Table 1: Table 1. Decomposition of H_2O_2(aq) at 300 K.

[H_2O_2] (mol/liter)	time (seconds)
2.32	0
2.01	200
1.72	400
1.49	600
0.98	1200
0.62	1800
0.25	3000

a) Show that the reaction is first order
b) Calculate the value of the half-life of this reaction
c) Suppose that the initial concentation of H_2O_2 were 3.5 M. How long would it take at 300 K to reduce the concentration of H_2O_2 to 25% of its initial value?